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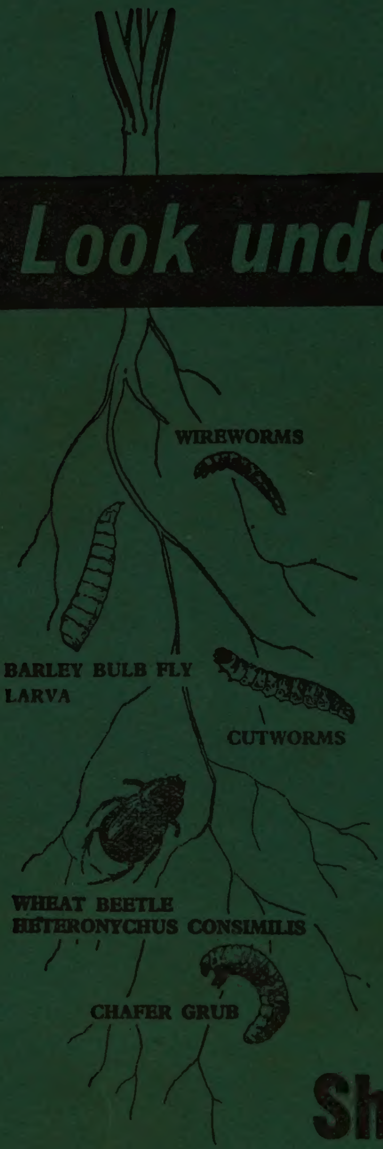

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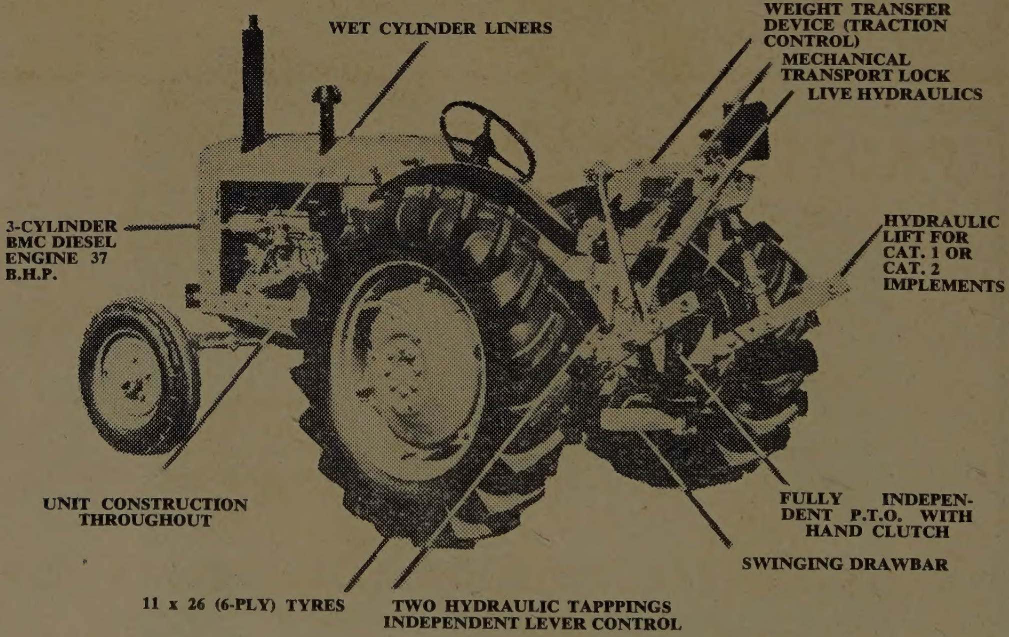
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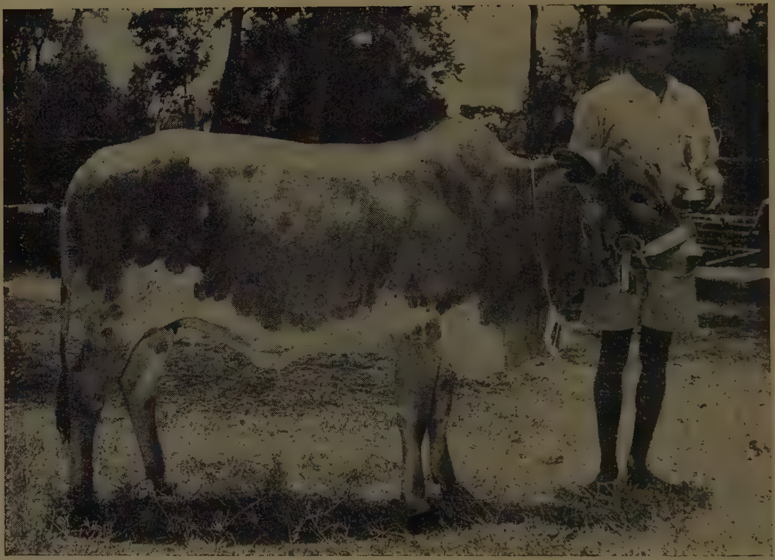

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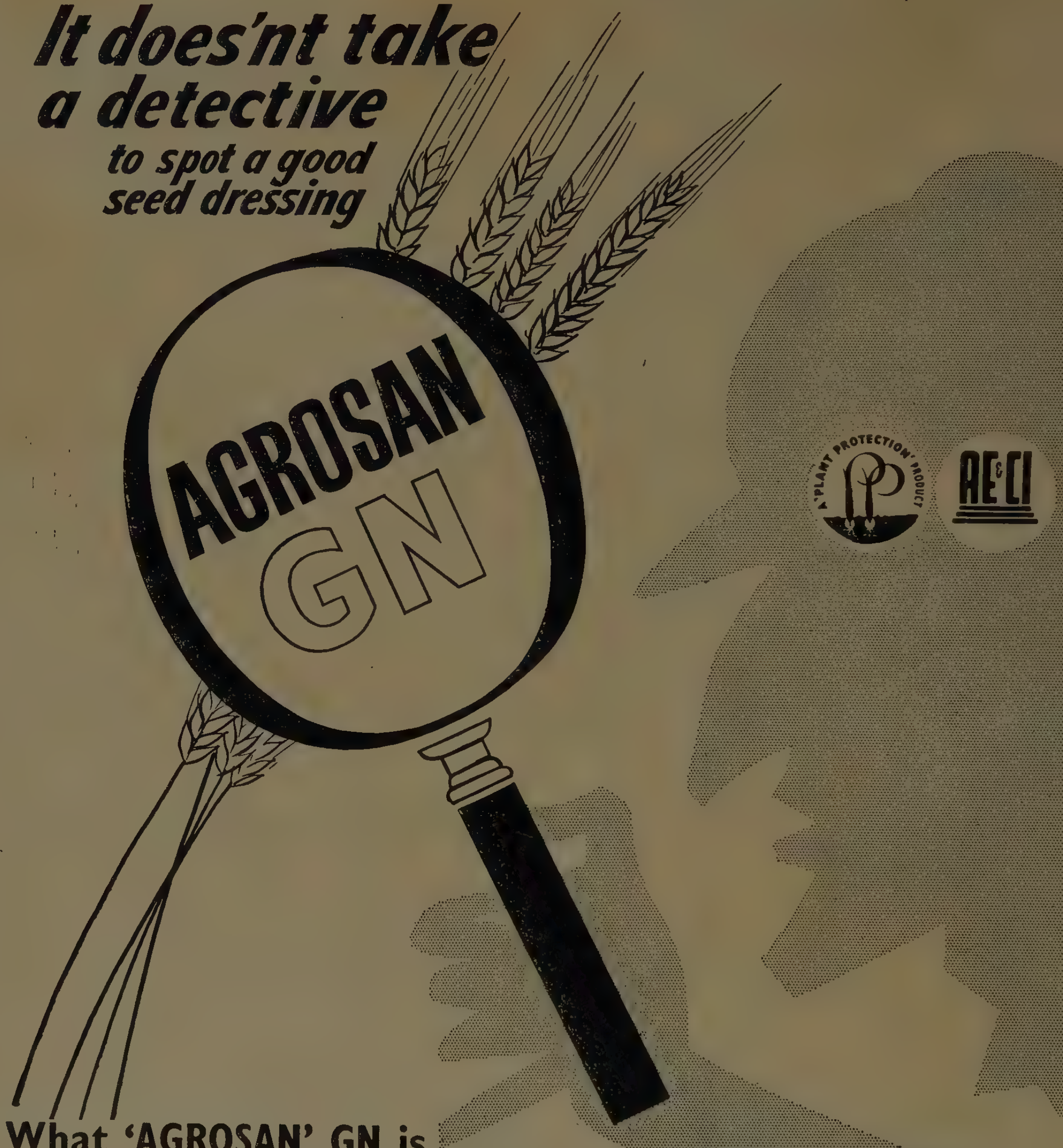
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CONTENTS

PAGE

The Management of Bacon Pigs (*R. A. Ayre-Smith*) 149

Reviews in Brief 160, 202

More about Dry-wood Termites (*W. Victor Harris*) 161

Problems of increasing livestock productivity in the intensive farming areas of Uganda (*D. J. Parsons*) 167

Tree Planting Trials for the control of the Red Locust (*Nomadacris septemfasciata*) in the Rukwa Valley, Tanganyika (*I. A. D. Robertson*) 172

Climatic Zones of East Africa (*J. F. Griffiths*) 179

The Effect of Insecticidal Spraying against *Glossina palpalis fuscipes* Newstead in the Nyando River Basin of Kenya (*R. Fairclough and W. E. F. Thomson*) 186

Gully Utilization and Erosion Control (*H. J. van Rensburg*) 190

A Method of Estimating Live-weights in Small Shorthorn Zebu Cattle from Linear Body Measurements (*John G. Ross*) .. 193

On the Estimation of Crude Fibre in Fodders and Concentrates (*H. W. Dougall*) 195

The Persistence of Insecticides in Tropical Soils. I—Preliminary Investigations (*J. Robinson and E. T. Mesmer*) 199

A Note on the Nutritive Value of Ramie Leaves (*Boehmeria nivae*) (*T. G. Cleasby and Osman Eff. Sideek*) 203

Breed Averages of Recorded Cows in Kenya for the year ending 1st July, 1957 (*E.A. Milk Recording Scheme*) 206

INDEX TO ADVERTISERS

PAGE

African Explosives and Chemical Industries (East Africa) Ltd. XII
Barclays Bank D.C.O. II
Dunlop Tyres .. .. COVER PAGE 4
East African Breweries Ltd. VII
Gailey & Roberts Ltd. VIII
International Harvester Co. (E.A.) Ltd. .. XI
Karlssons & Finne Ltd. V
Kenya Advertising Corporation Ltd. IX
May & Baker Ltd. .. .. .. COVER PAGE 3
Murphy Chemicals (East Africa) Ltd. .. IX
National Overseas and Grindlays Bank Ltd. VI
Ndurumo Ltd. X
Shell Company .. .. COVER PAGE 2, I
Smith Mackenzie & Co. Ltd. .. .. III, IV
Standard Bank of South Africa Ltd. .. VI
United Africa Company V
Wigglesworth & Co. (Africa) Ltd. II

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THE MANAGEMENT OF BACON PIGS

By **R. A. Ayre-Smith, Department of Veterinary Service, Kenya***

(*Received for publication on 6th September, 1957*)

Bacon production is an important part of Kenya's agricultural economy, and the sale of baconers may contribute considerably to individual farm profit. Like all livestock enterprises the production of baconers requires careful observation and attention to detail, therefore to assist those who are considering the raising of bacon pigs, and to encourage established producers to examine their methods of production, some of the details of raising baconers are stated here.

THE TYPE OF BACON PIG REQUIRED

Consumer demand for bacon is well defined and can only be met by marketing pigs of the correct shape. The value of a bacon carcass lies in the sides and hams, the fore-end being of less value. This requires that there should be considerable length between the shoulders and hams, the latter being well developed, broad and full to the hock, while the former should be light and blend smoothly with the sides. The back may be slightly arched, but must be of uniform width from shoulder to rump, and the neck and jowl should show no signs of coarseness.

A smooth skin and fine covering of hair indicate "quality", while "finish" denotes the well-filled even appearance of a baconer at marketing. Live-weight at marketing depends on the conformation of the pig, and is influenced by quality and finish, which, in turn, depend upon breed, feeding, management and housing.

CHOICE OF BREED

There are several breeds which possess good bacon conformation, and each has something to recommend it. By cross-breeding, the assets of two breeds may be successfully combined, for example the first cross between Large Whites and Saddlebacks combines the bacon quality of the former with the mothering ability of the latter. Yet it is fair to state that the Large White is generally regarded as the ideal bacon pig for most methods of production; while the Landrace of Scandinavia, a breed closely related to the Large White, is the near-perfect product of many years of improvement under ideal conditions.

FEEDING

Feed represents the largest single item of expenditure in feeding pigs to bacon weight. Over 75 per cent of the costs of production may be charged to the production and purchase of feeding-stuffs, while 15 per cent and 10 per cent may be debited to overheads and labour respectively. Not only is the feeding of pigs such a large item of expenditure, but the type of feeding practised influences the conformation and quality of the bacon carcass.

Bacon pigs are expected to grow rapidly from a birth weight of 2–4 lb. to a slaughter weight of 200–230 lb. live-weight. This requires that they receive easily digestible rations containing ample protein and carbohydrate, but little fibre. The time taken to reach bacon weight is largely determined by the type of ration fed. Under intensive systems of rearing some baconers will be ready for marketing at 25 weeks of age, while under more extensive systems, employing coarser feed-stuffs, bacon weight may not be reached until the pigs are over 30 weeks old.

Regardless of the system employed it is generally agreed that heavy weaning weights are required, that pigs must be kept growing rapidly for several weeks after weaning, that the rate of live-weight gain must be reduced in the latter part of fattening so as not to impair carcass quality, and that economy of feeding-stuffs can best be made by allowing expensive protein concentrates only when they are essential for rapid live-weight gains. Ideally, therefore, several rations containing varying proportions of protein should be available for feeding to pigs of different ages. But on a small enterprise the labour costs of preparing a number of rations would be greater than the savings in the use of feed-stuffs. Two or three rations are therefore recommended for the small producer, while the large producer, with several score of sows, may use four or even five rations.

---

* Present address: College of Veterinary Medicine, Baghdad, Iraq.

Since the feeding of sows is closely related to management, it is dealt with in the next section. The use of sow's milk replacers is also dealt with later. At this stage some of the more conventional methods of feeding pigs from three weeks old to bacon weight will be mentioned.

Creep Feeding

While still sucking the sow, young pigs will show an interest in solid food. If there is available a palatable high protein feed which is low in fibre, the piglets will consume ¼–2 lb. daily of it between the age of three weeks and weaning. Some producers, who value highly the benefits of creep feeding, will encourage piglets to eat solid food soon after they are two weeks old by offering them crushed maize, flaked maize or cake. Since creep feeds contain a high proportion of protein they are expensive and they are usually allowed to pigs in such a way as to exclude the sow. Weaning weights in excess of 35 lb. should be obtained when creep feeding is practised. Heavy weaning weights are usually considered a prerequisite of economical bacon production.

*Creep Feeds**

Ration 1—	*Per cent*
Maize meal	45
Barley meal	10
Pollards	10
K.M.C. Meat Meal B	15
Groundnut cake meal	7½
Soya bean meal	5
Cotton seed cake meal	5
Blood meal	2½

Ration 2—	*Per cent*
Maize meal	30
Barley meal	25
Pollards	15
High protein meat meal	10
Groundnut cake meal	10
Milk powder	10

Weaning

Towards the end of the sucking period it is advisable to commence mixing the creep feed with the sow-and-weaner meal which is being allowed to the sow. At the beginning of the piglets' seventh week a quarter of the creep feed should be replaced by the sow-and-weaner meal, and three days later half the creep feed should be so replaced.

*Sow-and-Weaner Meals**

Ration 3—	*Per cent*
Maize meal	30
Barley meal	10
Pollards	30
Bran	10
K.M.C. meat meal B	10
Groundnut cake meal	10

Ration 4—	*Per cent*
Maize meal	40
Barley meal	25
Pollards	15
Cotton seed cake meal	5
K.M.C. meat meal B	10
Groundnut cake meal	5

Piglets are normally weaned at 8 weeks old. For a further four weeks they should be maintained on the sow-and-weaner meal. *Ad lib* feeding may be commenced during this period. The use of automatic feeders is strongly advocated by some producers, but such feeders should be used only until the pigs have reached 100 lb. weight. The alternative is to ration pigs according to the average live-weight of the pen. Since it is always advisable to form pens of pigs as evenly matched as possible, in order to avoid bullying, this method of rationing is reliable. An allowance of 2 lb. of meal per day should be made to pigs at weaning, the actual amount being determined by their ability to clean up the trough in about 20 minutes. One week after weaning the amount will need to be increased by ½–¾ lb. per pig, and thereafter by ½ lb. per pig weekly. At 12 weeks old weaners should weigh between 70 and 80 lb. and they will be consuming up to 4 lb. of meal daily. Some producers will consider this excessive and they may prefer to allow 3 lb. of meal per pig daily at this stage. Yet it is well known that the cheapest gains are made when young, and it is believed that every encouragement should be given for young pigs to reach 100 lb. live-weight as quickly as possible. The meal should be fed twice daily at a routine time.

---

*A mineral and vitamin supplement to be added.

Fattening

At 12 weeks of age the meal ration may be changed, over the course of one week, to one containing less protein and more fibre. This will be a cheaper ration. Fattener I meals given below are examples of rations to be fed to pigs weighing from 80–120 lb. live-weight, that is between the age of 12–17 weeks approximately.

*Fattener I Meals**

Ration 5—	*Per cent*
Maize meal	35
Barley meal	35
Pollards	20
Cotton seed cake meal	5
K.M.C. meat meal B	5

Ration 6—	*Per cent*
Barley meal	30
Pollards	30
Maize meal	20
Oats (milled)	10
K.M.C. meat meal B	10

It is advisable to practise twice-daily restricted feeding from 100 lb. live-weight to slaughter. Pigs fed *ad lib* from weaning to 100 lb. live-weight, followed by twice-daily trough feeding, are considered to yield superior carcasses to those fed *ad lib* from weaning to slaughter, or those trough-fed right through to slaughter. The necessity to weigh the pigs regularly will be apparent. Rationing should not be based on guess work. When pigs are 100 lb. live-weight they require about 4½ lb. of meal daily and this should be increased to 5 lb. daily at 120 lb. live-weight.

From 120 lb. live-weight to 200 lb. at 24 weeks of age feeding is further restricted to avoid over-fat carcasses. Not only is the amount fed per day reduced relative to that allowed early in fattening, but the quantity and quality of the protein in the ration is reduced and the amount of fibre permissible is increased. Fattener II meals are recommended for use during this final stage. At an average pen weight of 120 lb. they will be changed from 5 lb. per pig daily of Fattener I meal to a similar amount of Fattener II meal. It is wise to make this change in two stages over the period of a week. At 20 weeks the average pen weight may be about 155 lb. and each pig will be receiving 5½ lb. of meal daily. At 24 weeks of age bacon weight will be obtained by some of the pigs in the pen. After they are 24 weeks old they will receive 6–6½ lb. of Fattener II meal daily. According to the breed and strain Grade A Quality bacon carcasses will be obtained from pigs weighing between 205 and 220 lb. live-weight (i.e. 130–175 lb. dressed carcass weight).

*Fattener II Meals**

Ration 7—	*Per cent*
Pollards	30
Cassava meal	25
Barley meal	30
Maize meal	10
K.M.C. meat meal B	5

Ration 8—	*Per cent*
Barley meal	40
Pollards	35
Maize meal	20
K.M.C. meat meal B	5

As an alternative to the use of Fattener I meals, the sow-and-weaner meals may be fed until the pigs are 110 lb. live-weight. They are then changed over to Fattener II meals.

The tables in the Appendix may be used as guides for compounding and feeding rations.

Methods of Feeding

Reference has already been made to the use of automatic feeders between weaning and 100 lb. live-weight. To allow young pigs to obtain their maximum growth potential the advisability of this method of feeding is rarely disputed, although it is not always practised. The twice-daily feeding of liberal amounts of meal during this period allows a better check to be kept on consumption. Feeding three times a day up to 100 lb. will result in superior live-weight gains, but against this advantage labour costs must be set. The continued use of self-feeders to bacon weight may well result in poor quality carcasses, and it is not, therefore, recommended. Nor is it recommended that pregnant sows be self fed.

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*A mineral and vitamin supplement to be added.

Wet-feeding of pig meal is frequently practised and wastage of meal is thereby reduced. The food is best prepared as a fairly thick porridge by adding 1½ gallons of water to every 10 lb. of meal. The dry meal may be placed in the trough and the water poured on top. This proportion should be kept constant. Amounts of water in excess of two parts by weight to one part of meal may have a deleterious effect on carcass conformation and quality.

Water

Some producers consider that the restriction of water to bacon pigs in the final stages of fattening is advisable. After pigs have reached the age of 20 weeks it is limited to that necessary to obtain a thick porridge with the meal. At all other times, when wet-meal feeding is practised, fresh water should be allowed at least once daily.

When the meal is fed dry a permanent source of fresh water may be provided in the pen. Alternatively the troughs can filled with water after each feeding in order to allow pigs to drink as much as they require. Piglets being creep-fed also require fresh water daily. A small trough about three inches high should be placed in the creep enclosure.

Feed Additives

Pigs of all ages require a mineral supplement. The composition of this supplement will vary according to the ingredients of the ration and to the age of the pigs. A mixture containing one part of flocculated lime, one part of bone meal and one part of salt has given satisfactory results in the past. One or two pounds of this mixture were recommended for every 100 lb. of pig meal.

It is now believed that small amounts of copper, when added to restricted meal diets, will increase live-weight gains. It is suspected that an excess of calcium may promote a deficiency of minor mineral elements, despite the fact that the calcium/phosphorus ratio is correct. Under intensive systems of production it is essential that a full range of minerals be allowed in the correct proportions. This may be best accomplished by the use of reliable proprietary mineral mixtures.

When green feeds or meals were not available it was the practice to add cod-liver oil to home-produced rations. One to three ounces per pig were added direct to the trough once or twice weekly. After 140 lb. live-weight, baconers received no further cod-liver oil, but there is a greater need for a wider variety of vitamins. Moreover these vitamins should be stabilized in order that the deleterious effects of climate or certain ingredients of the ration do not reduce their value. Powdered stabilized vitamin supplements are now available. The amounts required per ton of feed are small and adequate mixing is a problem, and therefore it may be considered advisable to purchase proprietary meals, fortified with stabilized vitamins, if intensive production is contemplated.

The value of supplementing the diet of fattening pigs with antibiotics is no longer disputed. Antibiotics stimulate growth in a number of circumstances, their greatest effect being with poor pigs fed poor rations, although even apparently healthy pigs fed correctly-balanced rations will benefit. There appears to be no advantage in feeding adult breeding animals with antibiotics, but neither is any harm done. The broad-spectrum antibiotics, for example chlortetracycline and oxytetracycline, give the greatest benefit under the widest range of conditions. Penicillin is effective with lower concentrations in the feed. The recommended level of antibiotic per ton of feed varies according to the age of the pigs. The full benefit of antibiotic supplemented feeds can only be obtained when they are fed continuously from three weeks of age to slaughter.

Under British conditions the cost of antibiotics in the feeding of early weaned pigs is high, yet early weaning would be hardly possible without their employment. The use of antibiotics in creep feeds is of great value. The feeding of antibiotics to baconers improves feed conversion efficiency and increases the rate of turnover in the piggery. These results are for healthy pigs, but the benefits of antibiotic feeding are greater when the stress of disease is experienced. In fact the feeding of antibiotics may be considered a worthwhile insurance against non-specific infections, but their use does not reduce the need for sound hygiene. The addition of antibiotics to the meals of pigs which are self-fed up to bacon weight has been reported to affect carcass quality adversely. Whether this effect was due to the antibiotic method of feeding or the ingredients of the basic rations is doubtful.

If antibiotic supplements are purchased they should be incorporated into the feed according to the manufacturer's instructions. Their use by this method has not always proved satisfactory, and reliable proprietary meals containing antibiotics may prove of greater value.

As methods of production intensify, pigs are inevitably subjected to increasing stress. Feed additives help to protect pigs against the deleterious effects of dietary, physiological and disease stress. The search for chemical and biological additives is great and their use complex. For intensive methods of bacon production the use of reliable proprietary pig meals containing a balanced range of feed additives has much to recommend it.

Grazing

Pigs benefit considerably from access to pasture, especially brood sows and weaners, but fatteners after 120 lb. live-weight are best finished to bacon weight without access to pasture. Grazing reduces feed costs and assists in the prevention of nutritional deficiencies, but pigs cannot deal with much fibrous material, and, therefore, to be of most benefit, pastures should be young and leafy. In this state one acre of grass will support four to six sows and their litters. A system of rotational grazing is to be commended. Pig-sick land must be avoided by alternate husbandry. A two-year rest every 18 months is ideal.

Dry sows at pasture require to be closely watched. Should any loss of condition be noted meal-feeding must be introduced. In-pig sows and gilts will require 4–6 lb. of meal in addition to the grazing they obtain. Stores may need 1½–3 lb. daily of a Fattener I meal. A mineral mixture must be supplied even if meal feeding is not practised. An adequate supply of fresh water needs to be provided and shade should be available. To avoid damage to the pastures it is necessary to ring pigs. For breeding stock a small bull-ring of one inch diameter is best used. Plain copper rings are satisfactory for weaners. The regulations regarding fencing contained in the Pig Industry (Paddocking of Pigs) Rules, 1951, must be followed by licensed pig producers.

If grazing is not available, green feeds should be fed in the sties whenever possible. Young grass, Russian comfrey, lucerne and sweet potato vines are some of the greenstuffs of value to pigs, especially farrowing sows. They should be regarded more as conditioners than meal replacements. A few pounds daily will help to maintain health.

Lehmann System

This is a system of feeding in which roots and tubers replace part of the balanced pig meal. Because of the low protein content of root crops a high protein supplement is generally recommended. To attain live-weight gains as great as those obtained under the more conventional methods of feeding, a meal containing 18 per cent of digestible protein is required. The expense of this meal may offset the expected financial advantage of the Lehmann System. Alternatively a lower protein supplement may be allowed. This will reduce the rate of gain but the overall economy of production may be still worthwhile.

A practice frequently employed is to allow weaners up to 3 lb. of a sow-and-weaner meal daily. When their appetite exceeds this amount of meal, potatoes or canna are added: these are best fed cooked. From 4–14 lb. are required daily according to age, but no more than 12 lb. of cooked potatoes should be allowed. Between ½–¾ ton of roots will be consumed up to slaughter weight, but root crops are not rich in minerals, and 3 lb. of a mineral mixture should be added to every 100 lb. of the meal ration.

Milk By-Products

Separated milk (and skim milk) is a valuable feed for pigs because of its content of high-quality protein. The effect on gains and health is greater than its chemical content would indicate. Nevertheless one must remember that it contains a high percentage of water and therefore large quantities are needed to replace a pound of balanced meal. The fat-soluble vitamins A and D are removed during the production of separated milk and an alternative source of these vitamins must be ensured. Seven to ten pounds of separated milk are reckoned to replace 1 lb. of balanced meal. When supplies are limited separated milk is best fed to weaners, as they will benefit most. Mix ¾ gallon in the weaner meal, reducing the total quantity of meal by 1 lb. For fatteners the use of a simple meal ration is possible provided adequate quantities of separated milk are allowed. A mixture containing two parts of barley and one part of weatings is sufficient from 80–120 lb. live-weight. From then on to bacon weight three parts of barley and one part of weatings may be used. Maize meal can replace 25 per cent of the barley. Two per cent of a mineral mixture should be added to these meals. Pigs will consume up to 1½ gallons daily of separated milk under this system, and 3–5 lb. of meal.

Souring does not affect the feeding value of separated milk provided it does not putrefy. Separated milk may be fed either sweet or soured, but whatever course is adopted it must be maintained. Changes are not advisable. Under commercial conditions it is often easier to feed soured milk consistently.

The feeding value of buttermilk is almost equivalent to separated milk and it will give as good results.

Whey is an unbalanced feed as it contains practically no protein. No meal-replacement value should be placed on whey until the pigs receiving it are about 16 weeks old. For pigs of this age one gallon of whey will replace about ¾ lb. of barley meal. During the fattening period up to three gallons may be allowed daily, but this requires that a higher level of protein be given than that supplied by a normal fattener ration. A sow-and-weaner meal would be suitable. During the last two weeks of fattening the quantity of whey should be reduced to 1½ gallons daily so as to avoid down-grading of the carcass. Whey should be fed sweet.

Effect of Feeds on Carcass Quality

Certain feed-stuffs have a marked effect on the type of fat laid down in the body. Soya beans, groundnuts and their cakes tend to produce a soft fat and a carcass of poor quality. Large quantities of oats, maize and rice bran fed during the final stages of fattening have a similar effect. Not more than 20 per cent of maize should be incorporated into a final fattener ration. Cotton seed cake, copra cake, barley meal, the grain sorghums, cassava meal and potatoes produce hard pig fat and carcasses of good quality.

Some fish meals and brands of cod-liver oil may flavour the fat. Such feed-stuffs should be omitted from rations during the last four weeks of fattening.

MANAGEMENT

Selection

Much of the success of bacon production depends upon the selection of sound breeding stock. A knowledge of the performance of mature sows and boars is essential for selection. This requires that farm records of their performance be maintained and that progeny records be consulted when possible. It is only by this means that it is possible to determine those sows which produce the large litters, which use their feed economically and that obtain good quality carcasses. Even when a breeding herd is not maintained a system of recording is advised to determine profitability and to indicate faults of management. In fact, some system of pig recording is essential for efficient production, and particulars of systems suitable for individual circumstances should be obtained from the Pig Industry Board or the Ministry of Agriculture.

Consideration of the records, conformation and breeding of sows will indicate those whose progeny it is desirable to use for herd replacements. Stud boars are frequently purchased from outside, the same factors being considered, but emphasis is placed on choosing a boar strongest in the character which is weakest in the herd on which it is to be used.

Young gilts are selected when aged between three and six months. At this age they may be fed a special ration to encourage good development. Rations 9 and 10 are examples. Alternatively a Fattener I meal can be used. Adequate exercise assists the development of a good frame. Gilts must not be allowed to become over-fat. Well-developed gilts weighing about 280 lb. and being over eight months old may be put to the boar.

*Ration 9**	*Per cent*
Maize meal	20
Barley meal	40
Oats (milled)	20
Lucerne meal	12½
Cotton seed cake meal	5
KMC meat meal B	2½

*Ration 10**	*Per cent*
Barley meal	30
Oats (milled)	30
Bran	20
Lucerne meal	10
Copra cake meal	5
K.M.C. meat meal B	5

Provided they are well-grown, boars are generally allowed their first service when 9–10 months old. They must be used sparingly at first and given only one or two gilts per month. When mature, a boar can serve 30–40 sows a year provided the services are evenly distributed. If a considerable difference exists between the size of the boar and the sow the use of a breeding crate will facilitate service.

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*A mineral and vitamin supplement to be added.

A boar in service should receive 1–1½ lb. of a sow-and-weaner meal daily per 100 lb. liveweight. He should be kept in thrifty condition and allowed exercise, preferably on good pasture.

Breeding Routine

Provided a sow is not pregnant or nursing a litter she comes on heat about every 21 days. Heat lasts from three to four days and the ova are usually shed during the second day. It is common practice to allow the boar to serve the sow on the first day on which heat is noticed and again on the following day. Whenever possible, the sow should be kept quiet immediately after service, otherwise she may lose part, if not all, of the ejaculate.

A record should be made of the date of service, and signs of heat watched for in three weeks' time, when the sow should be tried again with the boar. If heat does not reappear it may be assumed that the sow is pregnant, although this assumption is not infallible. Where market conditions are secure it is advisable to have several sows farrowing at the same time. This facilitates herd management and the matching of pigs during fattening.

The period of gestation is from 113–116 days or, about "three months, three weeks and three days". During the first half of pregnancy sows should be fed to gain ½–1 lb. daily, although few producers practise the weighing of sows. Rations 9 and 10 are suitable for this period or a Fattener I meal may be allowed. During the latter half of pregnancy sows should be changed to a sow-and-weaner meal. Exercise is essential and allowing sows access to pasture is advisable. When good grazing is available in-pig sows require 3½ lb., 4½ lb., 5½ lb. and 6½ lb. of meal daily during the first, second, third and fourth months of pregnancy. If sows do not have access to pasture the amount of meal should be increased by 1½ lb. a day.

Ten or 11 weeks after service it may be advisable for the sow to receive an anthelmintic for the expulsion of roundworms. A week before she is due to pig the dose of anthelmintic may be repeated, after which she should be removed to a farrowing pen. This must be thoroughly clean and contain a small amount of short bedding. A farrowing rail, 9 in. from the wall and 9 in. from the ground, may help to prevent a clumsy sow from crushing young pigs, but the use of such rails is not advocated by all producers. Specially designed farrowing houses and the use of piglet nests also help to avoid any tendency for the sow to crush her piglets. Overlaying by sows is the most important cause of the pre-weaning mortality of young pigs. However, it is not satisfactory to attribute this merely to the shortcomings of a clumsy sow. Lethargy of the young pigs can be a contributing factor, and this may be due to faulty nutrition.

Prior to pigging, the sow should be handled gently. It is also advisable to wash her udder with soap and water in order to remove any worm eggs which may be adhering to it. The ration should be made more laxative by the addition of bran and the amount reduced by one-half a day or two before the anticipated time of farrowing. Green feed is valuable during this period. While farrowing a sow should not be disturbed, but she must be kept under observation. Should excessive numbers of piglets be born it is advisable to kill the runts a day or two after farrowing, unless an attempt is to be made to rear these on special rations containing antibiotics. If the number of piglets produced is greater than the number of functional teats possessed by the sow it may be possible to transfer some to a freshly farrowed sow, who has only produced a small litter. A record should be kept of this transfer.

On the first day after farrowing no food should be given, but the sow will require plenty of water to drink. On the second day 2 lb. of a sow-and-weaner should be allowed as a slop, and the amount doubled two days later. During the second week the meal allowance should be increased until the sow is receiving all that she will consume. As a guide an allowance of 6 lb. of meal for the sow and ½ lb. for each piglet may be used. During the suckling period a sow will drink between 5–10 gallons of water daily.

Around the third week the sow's supply of milk begins to decrease. The three-week-weights of young pigs are a good indication of the milking ability of the sow, and they should be between 12 and 15 lb. If creep feeding is to be practised it should commence at this stage.

When the litter is 4–5 weeks old, boar pigs not required for breeding purposes are castrated, and all piglets in the litter marked. Notches cut in certain parts of the ear are usually employed to identify individuals. (*See* Appendix.) At eight weeks of age the litter is weaned. A record of the numbers weaned and their weights should be made, this being a good indication of the efficiency of management.

A few days prior to weaning the meal allowance of the sow should be reduced, and weaning is best accomplished by the removal of the sow to another pen. About five days later she will normally come on heat. Unless in very low condition she should be served at this time. The aim is to obtain two litters per sow each year of an average size of eight weaned pigs per litter.

Artificial Rearing and Early Weaning

In Europe and America two new types of baby pig feeds have been marketed in the last few years. For the emergency feeding of pigs that cannot be brought up normally, proprietary sow's milk replacers are available. These replacers are fed mixed with water for the first few days of the pig's life. Later, dry feeding is practised. Special feeders are not employed, shallow troughs 3 in. high being suitable. Fresh gruel is kept in the troughs all the time, but the troughs are thoroughly cleaned daily.

These proprietary mixtures have largely replaced home-produced sow's milk substitutes which were based on cow's milk. An example of the latter is as follows: to each gallon of cow's milk add two pints of lime water, eight tablespoonfuls of medicinal glucose, 2½ tablespoonfuls of sodium citrate and five drops of halibut oil emulsion per pig daily. The inclusion of some soluble form of antibiotic is advisable. The above mixture needs to be fed six times a day during the piglets' first three weeks of life, about a pint being sufficient for six to eight piglets at each feed. When they are three weeks old, about two pints will be required per pig daily, three meals a day being sufficient. For the first day or two the mixture should be given at blood heat, later it may be given cold. Scrupulous cleanliness of all feeding equipment is essential, and the pigs must be provided with a warm pen free from draughts. The use of an artificial source of heat is recommended. Soon after birth prophylaxis against piglet anaemia must be adopted.

If early weaning is required the dry feeding of a sow's milk replacer commences when the pigs are about 14 days old, the sow remaining with the piglets for a further few days during which time they will become fully accustomed to the dry meal or pellets. From the age of a week old, water should be offered to the piglets separately. A creep feed may still be employed, a change being made from the sow's milk replacer to the creep feed over a period of three weeks, so that at eight weeks old the young pigs are receiving whole creep feed.

When the productivity of a pig enterprise is of a very high standard the early weaning of pigs will yield benefits: heavy weaning weights will be obtained: the sow may be returned to the boar within three weeks of farrowing, and it should be possible to obtain three litters per sow in just over a year: sows do not undergo the heavy drain of lactation and so are maintained in good condition: the number of runt pigs is reduced because food is freely available: and the risk of young pigs being infested with roundworms is minimized.

A warm, draught-free pen must be provided and sufficient light should be available in order that the young pigs can see the food and water throughout the 24-hour period, during which time it must always be available. When possible the use of bright emitter infra-red lamps is advised for the first two or three weeks. Strict attention must be paid to hygiene. Between 1¾ lb. and 2 lb. of sow's milk replacer will be required per lb. live-weight gain from birth to weaning. Average daily consumption per pig will increase from 1 lb. daily at two weeks to 2½ lb. daily at weaning; water consumption will increase from ½ gallon daily to over 1 gallon during this period. While still on the sow piglets must be dosed with iron to prevent anaemia.

Artificial Insemination

Because of the pig's ability to reproduce rapidly, its high prolificacy and early maturity, the potentialities of artificial insemination are great. If the wide use of boars is practised it must be ensured that these boars are of the highest standard. This can only be done by vigorous veterinary control and the comprehensive testing of boars at progeny-testing stations.

The collection of boar semen is not as simple as the collection of bull semen, but a satisfactory technique has been evolved. The dilution and storage of boar semen is still a problem. Insemination requires skill and care. The correct timing of insemination is a difficulty. In Britain the practice of artificial insemination in pigs is expected to expand during the next decade and great benefits are anticipated provided adequately-tested boars are used. With similar safeguards its practical application in Kenya can be expected to be of considerable value.

Disease Prevention

Some of the more common diseases of pigs have been discussed in "Notes on Animal Diseases", compiled by the Department of Veterinary Services, Kenya. (*See* "Notes on Animal Diseases" XI and XXI, originally published in the *East African Agricultural Journal.* Reprints are obtainable from the Department of Veterinary Services, Kabete.) The Pig Industry (Paddocking of Pigs) Rules, 1951, orders that certain measures be adopted by licensed pig producers. A reason for these is to prevent infection and spread of African swine fever.

The incidence of contagious and infectious diseases tends to increase when pigs are subjected to the stress of artificial methods of production. To minimize the risks associated with this stress, feeding, housing and hygiene must be sound.

Infestation with various types of internal parasites is common and seriously reduces productivity. The incidence of the roundworm, *Ascaris lumbricoides,* is high and the routine use of an appropriate anthelmintic should be employed in all herds. Sodium fluoride has proved effective for the treatment of roundworms in pigs, it is cheap, easy to administer and its use is attended by little risk. (Note that sodium fluoride must not be given in liquid.) After weaning pigs are frequently dosed twice at an interval of three weeks. Sows should be dosed once during pregnancy, but the continued use of sodium fluoride throughout the life of a sow may give rise to ill effects.

Piperazine compounds have recently proved most successful for the elimination of the roundworms of pigs. They effect both ascarids and nodular worms. Wet or dry feeds are suitable vehicles for their administration. No ancillary treatment is required. Young pigs should be dosed about a week after weaning, and pregnant sows should be treated a few days before being placed in their farrowing houses prior to parturition.

The routine use of anthelmintics must be accompanied by sound hygiene and management. Dirt and dampness favour the development of worm eggs to the infective stage. Clean, dry quarters are essential if infestation is to be prevented. Pigs should not have access to dung heaps, and contamination of food and water must be prevented. As already explained, washing a sow's udder prior to farrowing will reduce the likelihood of the newly-born pigs being infested with worm eggs. This should be done before she is introduced to the farrowing house. Disinfection of farrowing houses is accomplished by the use of hot caustic solutions, e.g. hot 2 per cent soda lye or 4 per cent Magadi soda.

If young pigs and sows are to be run at pasture, the latter should not have been used by other pigs within the last year. After pigs reach the age of four months, considerable resistance to roundworms develops. Nevertheless care must be taken to avoid the use of heavily infested pastures by pigs of all ages.

Piglet anaemia is caused by a deficiency of iron and copper, and it is often associated with chilling. It appears most frequently in pigs reared indoors, and may be accompanied by piglet influenza and infectious pneumonia. Paleness of the skin and mucous membranes, yellow scours and laboured breathing are indicative of the complaint which occurs mainly when the pigs are three to four weeks old. Various proprietary preparations are available for the prevention of anaemia. Capsules or pastes can be made from locally purchased iron and copper compounds. Allowing intensively reared pigs access to a sod of earth each day will often prevent the complaint. Preventive measures should be adopted on the third or fourth day of life.

Every effort should be made to isolate newly purchased pigs from the main herd for 28 days. Such a quarantine period allows time for symptoms of infectious or other diseases to develop without risk of affecting the main herd. If symptoms of ill-health appear, a veterinary surgeon should be consulted. Under the artificial conditions of feeding, housing and management to which pigs are subjected the balance between health and disease is delicate, and timely advice will help to prevent losses.

HOUSING

It is not necessary for good housing to be elaborate, but pig buildings must be warm, dry and free from draughts. Good housing is as vital to successful pig production as good feeding. In fact the two are complementary, since the efficiency of the conversion of feed into live-weight gain is closely related to the standard of housing. Good housing, therefore, favourably affects the profitability of a pig enterprise.

The type of housing will depend on economic considerations, on the availability of building materials and on the kind of pig enterprise. It is not possible to suggest an ideal house to suit a wide variety of conditions, but before constructing new buildings or modifying old ones technical advice should be obtained. In brief the following requirements must be met.

Breeding Units

On a large-scale pig enterprise special farrowing accommodation is often provided. Farrowing crates may be used to allow maximum control of the sow, but many producers prefer simple pens. If a creep is not provided the dimensions of the pen should be 9 ft. × 9 ft., and a protective rail may be fixed 9 in. from the surrounding wall and 9 in. from ground level.

The provision of a yard, 8 ft. × 5 ft., is advisable. The yard is for exercise, dunging and in it feeding may take place. Isolation of sows and piglets must be attempted in order to prevent the spread of disease. The yard should not, therefore, communicate with others. Part of it should be covered by a porch in order to protect the sow and young pigs, when feeding and dunging, from inclement weather. Pigs are prone to soil their bedding if the dunging area is cold and exposed to rain.

Farrowing pens require to be kept between a temperature of 60 deg. to 70 deg. F. Diurnal variations must be avoided and this can best be done by making the sleeping quarters into kennels by the provision of low, insulated roofs. Ventilation to a kennel can be increased during the heat of the day by simply lifting the roof or opening sliding panels.

Young piglets require to be maintained at a temperature of 70 deg. to 80 deg. F. This is hard to accomplish unless partitioned-off nests are incorporated in the kennels. It may be necessary to supply these nests with some source of artificial heat. Creep feeding is generally recognized to be essential for profitable bacon production. It can be accomplished by using small troughs behind sow-proof bars. It is important that the creep should be light, otherwise consumption of feed will be reduced, and water must be available beside the feeder.

Portable huts and arks may be successfully used outdoors. Sufficient ground must be available to allow them to be moved frequently. If a fold unit is attached grazing control is facilitated. When used for farrowing, huts and arks should have a door at the end opposite to the pig entrance. This will allow assistance at farrowing. Whatever type of hut or ark is contemplated it should be insulated to avoid extremes of temperature, and draughts must be excluded. The provision of a piglet nest and creep feeder is advised.

Feeding Units

A bacon pig requires 5 sq. ft. for bedding, 8 sq. ft. for feeding and dunging and 13 in. of trough space. The minimum width of the pen at the trough should be 5 ft. The temperature of the bedding area should be maintained between 60 deg. and 70 deg. F. Raised beds and bedding kerbs will prevent the area from being soiled. The fall of the floor in the bedding area may be slight, but in the dunging area a fall of 1 in 15 should be made. Floors must be warm and roughly finished.

If a kennel-type piggery is designed, ventilation is not a problem since pigs obtain fresh air when they leave the insulated bedding area. A baffled exit is suggested to avoid draughts, while allowing air circulation in the kennel. Some control of ventilation is advisable in the kennel for emergency use during hot weather. This may be similar to that suggested for farrowing kennels, namely a lifting roof or sliding panels. Ventilation and insulation of the building in which the kennels are constructed need only be elementary.

Should kennels not be used, then insulation and ventilation must be carefully planned. Baffled inlets are best placed below the eaves and central extract vents, with controlled shutters, should provide 4–6 sq. in. cross-section area per pig. Well designed and insulated roofs are of great importance.

Insulated buildings are expensive to construct and controlled ventilation is difficult to design. The alternative use of farrowing and fattening kennels in simply constructed buildings is therefore recommended. The kennels are warm and draught-proof. In the part-covered yard attached, light, fresh air and exercise are easily obtained. The pig is free to dung away from its bed and the essential provision of a dry bed is therefore obtained. Isolation is satisfactory and cleaning out is not a burden, since only the daily removal of faeces from the dunging area is required. An easy system of feeding can be operated and, if it is not practised in the kennel, wet feeding will not adversely affect the humidity of the bedding area.

The use of pig kennels is to be encouraged in Kenya where, despite the equatorial position, temperate conditions prevail in most areas of bacon production.

APPENDIX I—FEEDING GUIDE FOR BACON PIGS

Age in Weeks	Liveweight	Lb. of meal per pig daily*	Liveweight increase per day	Feed conversion efficiency. Lb. feed per lb. liveweight gain	Ration	Per cent Digestible Protein	Nutritive Ratio	Per cent Crude Fibre
	lb.		*lb.*					
3	12	·25	—	—	Creep Feed	18–20†	1 : 3	3
8	40	2·0–2·5	·80	2·5	Sow-and-Weaner	15–18†	1 : 4	4
10	55	3·0	1·0	3·0				
12	72	4·0	1·2	3·3				
14	90	4·5	1·3	3·5	Fattener I‡	13–14	1 : 5	5
16	110	5·0	1·4	3·6				
18	130	5·25	1·4	3·7	Fattener II	10–12	1 : 6	6
20	152	5·5	1·5	3·7				
22	175	6·0	1·6	3·7				
24	200	6·5	1·7	3·8				

*An alternative guide is to feed 1½–2 lb. of meal at weaning, and to increase this amount by ¼ lb. a day each week up to a maximum of 6 lb.

†Half the protein rich feeds to be of animal origin.

‡The use of this ration may be omitted, the sow-and-weaner meal being fed until 110 lb. liveweight, followed by the Fattener II.

APPENDIX II

Substitute Feeds

(Based on the recommendations of the Department of Veterinary Services Kenya; first published in the Official Bulletin of the Pig Industry Board of Kenya, Vol. I, No. I, April, 1956.)

10 LB. OF MAIZE OR BARLEY MEAL ARE REPLACED BY:

Lb. of feed	Name of feed	Maximum permissable in ration	Remarks
13	Oats	20% sow-and-weaner .. 30% fattener.	Grind finely.
11	Wheat	25% of all rations.	Grind coarsely.
11	Cassava meal	30% of all rations ..	Hardens carcass fat. Deficient in protein and minerals.
12	Sorghum	60% of all rations ..	Grind finely. The husk of red is unpalatable Hardens carcass fat.

10 LB. OF POLLARDS ARE REPLACED BY:

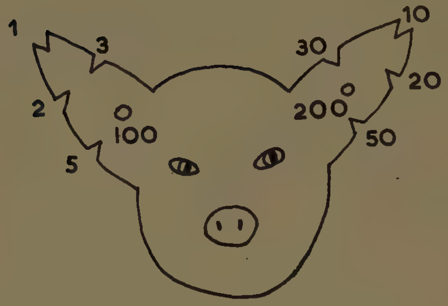
Lb. of feed	Name of feed	Maximum permissable in ration	Remarks
12	Bran	10% of all rations.	Improves texture of pasty feeds.
11½	Lucerne meal	10% sow-and-weaner. 20% fattener.	Rich in calcium.
7	Copra cake	15% of all rations.	Hardens carcass fat.
9	Rice dust.	25% of all rations.	Softens carcass fat.

10 LB. OF K.M.C. MEAT MEAL B ARE REPLACED BY:

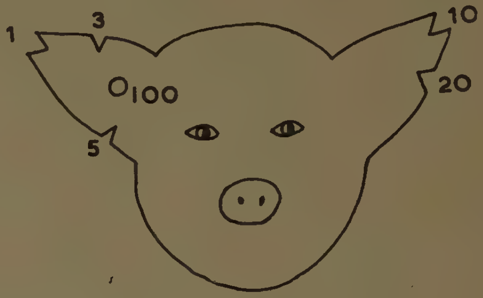
Lb. of feed	Name of feed	Maximum permissable in ration	Remarks
7	K.M.C. Meat Meal A ..	10% of all rations.	May cause scouring if in excess.
10	Decorticated cotton seed cake.	7·5% of all rations.	Hardens carcass fat. Risk of poisoning if in excess.
8	Decorticated groundnut cake.	10% of all rations.	Softens carcass fat.

Appendix III

Earmarking



PLACING OF NOTCHES



EXAMPLE = 139

REVIEWS IN BRIEF

Olive Oil Processing in Rural Mills, by G. Frezzotti, M. Manni, and A. Aten. F.A.O. Agricultural Development Paper No. 58, 1956, published by the Food and Agriculture Organization of the United Nations, Rome. Price: $1.00 or 5*s*.

The senior author of this booklet of 103 pages is Director of the Olive Oil Processing Experimental Station in Spoleto, Italy. All aspects of the olive oil industry are dealt with in summarized form, from the olive tree and its fruit to new trends in olive processing. Methods and processes, tools, implements and machinery are described in broad outline only but more detailed information is available from the Food and Agriculture Organization.

Colonial Agriculture Statistics. The Organization of Field Work, by K. E. Hunt. Colonial Research Publication No. 22, published by H.M. Stationery Office, London, 1957. Price: 14*s*.

This is substantially a revised version of "Statistics for Colonial Agriculture" which appeared in October, 1951. Since that time, experience of agricultural statistics in the Colonial territories has accumulated at a rapid rate, particularly in connexion with Sample Surveys, and the need to review the additional information has given rise to this publication.

Wheat Production in Kenya, 1955/56. An Economic Study, prepared by E. S. Clayton of the Economic Research Division of the Kenya Treasury, published by the Government Printer, Nairobi, Kenya, 1957. Price: Sh. 2.

A study of the costs of production of wheat in Kenya, with a section on farm budgeting and Appendices on the Wheat Cost Inquiry, 1955/56 and the Tractor Cost Inquiry, 1955/56.

Annual Report of the Sisal Research Station, Ngomeni, Tanganyika for the Year 1956. Obtainable from the Tanganyika Sisal Growers' Association, Tanga, Tanganyika.

This report reviews progress in field experiments, herbicide and arboricide trials, plant physiology, soil chemistry, and spectrographic chemistry.

Sif tips. A quarterly welding journal, published by the Suffolk Iron Foundry Ltd., Stowmarket, Suffolk, England. Annual subscription: 2*s*.

This periodical reviews the latest developments in welding technique, with numerous illustrations.

British Chemical Engineering. A monthly journal on production problems involving chemical engineering techniques in all spheres of industry. There is a Free Reader Inquiry Service. Annual subscription: 30*s*. or $6.00. Published by Heywood and Co. Ltd., Drury House, Russell Street, London, W.C.2.

MORE ABOUT DRY-WOOD TERMITES

By W. Victor Harris, Colonial Termite Research Unit, British Museum (Natural History), London

(*Received for publication on 19th August, 1957*)

The striking differences in habit between the dry-wood termites and the ground-dwelling members of this family of insects are generally recognized, as indicated by the way in which different popular names are given to them in many countries. For example, dry-wood termites are often called "borers" or "flying termites", while the ground dwellers go by the name of "white ants". In Latin America the common names are "polilla" and "comejen" respectively; though both these terms appear to be used for other pests as well. It is of great practical importance to appreciate that dry-wood termites are in fact termites and not beetles or any other kind of insect, just as it is also of importance to bear in mind the ways in which their behaviour and social organization differ from their subterranean or mound-building relatives. It is not surprising that in the Old World Tropics "white ants" are associated in most people's minds with the mounds, large or small, which are frequently a conspicuous feature of the landscape. Thus it is that in dry countries like Arabia where mounds are scarce or quite absent, termite damage to buildings comes as a surprise.

A preliminary note on dry-wood termites appeared in this *Journal* for July, 1950, since when there has been an increased awareness of the damage which termites can do in East Africa, there has been an increase in dry-wood termite activity in the coastal plain, and there has also been an increase in our knowledge of these pests which may assist those who wish to deal with the problem.

BEHAVIOUR OF DRY-WOOD TERMITES

Dry-wood termites are so-called because they feed on and live in dry wood. The families live in galleries which have been excavated to provide food, just as borer beetles, some caterpillars and other insects do. Dry-wood termites are able to digest the cellulose of wood by the aid of large numbers of simple, single-celled animals called protozoa which live in their gut. Most of the other termites have no such protozoa to assist them, and they cope with cellulose by using it first to make "fungus gardens" in their nests, by extracting it from soil after it has partly decomposed as a result of bacterial or fungal action, or from wood which has started to decay. As a result of their ability to feed on wood, dry-wood termites do not need any contact whatever with the ground to obtain moisture or supplementary foods.

A colony of dry-wood termites numbers at most a few hundred individuals, as compared with the thousands and even millions living in mounds or subterranean nests. There is in each community a king and queen, who are the parents, and a small number of individuals with large heads and massive jaws who perform a defensive role and are accordingly called soldiers. The bulk of the population is made up of young termites of various ages and sizes who may ultimately grow to be winged adults, but which do all the hard work of the community once they have ceased to be infants, and until their wings are developed. Some nymphs never complete their development but keep on working for the rest of their lives. Other nymphs become kings and queens without flying in the normal way, if they are required to replace the original parents, or if they belong to a section of a community which has become detached from the main body and then develops into a self-contained unit on its own. Nymphs are white or pale cream in colour. They become dark only at the final moult which turns them into adult termites, ready to fly off into the outer world. The soldiers have pale bodies, but their enlarged heads are hard and black. The soldiers are of considerable value in naming dry-wood termites, since their size and shape varies from one species to another, whereas the nymphs are all pretty much alike. The jaws of the soldiers are large and spectacular, but the smaller jaws of the nymphs are in effect much more efficient, and enable them to excavate all but the hardest of timbers.

There are 236 different species of dry-wood termites known from the various parts of the world, but the great majority are "wild", in the sense that they live in the dead branches of trees, or in the fallen trunks of large trees not yet decayed. They may accelerate the process of dying by gnawing the cork layers which the tree endeavours to place as a barrier between the living tissues and the dead wood. A few dry-wood termites, mainly belonging to the genus *Cryptotermes,* are able to live in hard, sound wood—dead, of course—which is used as timber, and these have become "domestic" and capable of sharing the buildings which we erect. Several of these "domestic" *Cryptotermes* have been introduced into new countries where they remain solely as pests of buildings and either from choice, or because they cannot compete with the local species, they are never found "wild".

Dry-wood termites produce adult forms with wings which leave the community in mass flights or "swarms". Unlike most of the ground-dwelling termites which swarm only once or twice a year in impressive bursts, dry-wood termites swarm little and often throughout the rainy season, and in particularly wet climates may do this throughout the greater part of the year. Naturally where the wet and dry seasons are quite distinct swarming is restricted to the wet season.

Plate I.—Damage to wooden gate in harbour area, Dar es Salaam, by Cryptotermes dudleyi.
[Photo: W. Wilkinson

If a part of a community becomes detached as, for example, when a piece of timber is taken from an infested house or wood-store and placed in a different building, the dry-wood termites therein may cause a number of their nymphs to become mature without undergoing the number of moults required to achieve an adult appearance. These supplementary reproductives produce fertile eggs and so the community grows and the termites become established by a process of "budding" and not by two flying termites during the swarming season. This is of great practical importance, as it may well be the main source of infection not only of new buildings, but of new countries. The chances would appear to be greater.

How to Recognize Dry-wood Termite Damage

The presence of dry-wood termites is usually indicated by small heaps of frass or faecal pellets on the ground beside or below infested woodwork, or filling galleries inside a piece of timber removed for inspection. This frass is superficially like that made by furniture beetles or bamboo borers, but on closer inspection is found to be of uniform size, regular in shape, oval and seed-like. At intervals the termites make small holes from their galleries to the surface and push out the accumulated frass, then they seal up the holes with chewed wood and saliva and resume their hidden activity. Inside the infested timber the extent of the excavations depends on the age of the termite community, ultimately there being only a thin outer shell of wood supporting the layer of paint or varnish, with a few slender partitions inside to act as struts. Domestic dry-wood termites will attack roof-members, ceiling and floor beams and boards, door frames, window shutters, and of course furniture. Books and anything else that are made from cellulose will be destroyed if they are in contact with infested woodwork. Heart-wood and sapwood, plywood and veneers are all liable to harbour them unless naturally resistant or made so by impregnation with termite-repellant chemicals. Paints and varnishes offer some protection, but only so long as they form an unbroken coating. Cracks and joints are the usual places where an attack starts, and cases have been reported of doors becoming infested via the keyholes.

The trouble starts with the arrival of a pair of flying termites, who discard their wings and set about seeking a suitable crevice or otherwise secluded spot where they can set about digging themselves in. Once inside the wood they seal up the entrance hole with chewed wood, and there is, thereafter, no outward sign of them until the family has developed to the stage when they must make their first opening to the surface to tip their refuse outside. Ultimately the community develops to the stage of producing winged adults, a matter of several years as a rule. When the time for swarming arrives, tunnels are again bored to the surface through which the flying termites reach the open air. With this change of many nymphs into adults and their departure from the nest, there is a reduction in wood boring for a time until eggs are laid and the new nymphs grow to a stage when they can start collecting food. This produces a cycle of activity which is not so general among the ground-dwelling termites, whose food collecting activities are the duty of a special caste of workers. Although the population of an individual dry-wood termite colony is small and can exist happily in a few cubic inches of timber, these termites achieve their high degree of damage by sheer weight of numbers of colonies, all living close together.

Prevention and Cure of Dry-wood Termite Attack

When designing a building for any situation in the Tropics at an elevation below 8,000 feet above sea-level, it is profitable to give some thought to the problem of preventing termite damage for a reasonable period of time. This includes the protection of furniture and fittings and anything else the building is likely to contain, for an all-metal-and-concrete structure may not in itself be liable to termite damage but it will fail in its purpose if termites can destroy its contents, especially if it is to be used as a store or warehouse. Unfortunately constructional measures, which will successfully prevent ground-dwelling termites from entering a building, are of no avail in an area where dry-wood termites are present. Flying termites will gain an entrance through open doors and windows, through ventilators and gaps under the eaves, and on finding suitable exposed woodwork will go inside. It must be stressed here, however, that the risk of infestation from the outside by the rather feeble flying termites exposed to so many enemies and to the danger of not coming across a mate, is small compared with the practical certainty of infection which results from the use of timber containing a few living termites or by bringing into the completed building furniture and fittings already infested. Should it be thought that these last two methods do not happen because the risk is so obvious that people would not do such things, consider the case of St. Helena where the extensive damage done by the West Indian dry-wood termite (*Cryptotermes brevis*) arises from the use as roof beams of timber taken from a boat captured during the Napoleonic Wars and brought as a prize to Jamestown. I have seen in a new colonial Government House, occupying a prominent place in a lounge panelled with local timbers, an antique table brought from the old Government House and from which flying Cryptotermes had been observed to emerge at intervals (though not recognized as such at the time, apparently). The heavy infestation of *Cryptotermes brevis* in coastal towns in Natal is generally regarded as having originated in a piece of furniture brought to Durban about 1921, though I would suggest the possibility of an earlier introduction when timbers from wooden ships were used in buildings in Port Elizabeth and elsewhere, especially after some of the many shipwrecks along that stormy coast. The introduction of infested furniture can be avoided by careful inspection and by measures to kill the insects if their presence is suspected. Fumigation with methyl bromide, or soaking in a wood preservative of suitable penetrative powers will achieve this.

Plate II.—Typical heaps of frass near base of packing case infested by Cryptotermes dudleyi, at Zanzibar. [Photo: W. Wilkinson

Constructional timber should be resistant to dry-wood termites. "Resistance" is a relative term, and a property which decreases with time. Certain hardwoods are known which are naturally resistant to dry-wood termites for a very long time, but eventually their defence weakens, usually as a result of weathering, or of exposure to damp conditions which permit the development of fungi. A leak in a roof, or a faulty water system will curtail the useful life of the best timbers. Among the timbers whose heart-wood is resistant to termite attack for many years we note West Indian mahogany, *Swietenia mahogani,* teak, *Tectona grandis,* mvule, *Chlorophora excelsa,* and belian, *Eusideroxylon zwageri.* An additional point in design which is less fashionable nowadays than it used to be, is the use of timbers of dimensions greatly in excess of the minimum needs of the structure. Such excess permits of a certain amount of insect damage before the structure is weakened to breaking point, and the value of this may be seen not only in the older buildings along the African coasts where dry-wood termites are at work, but in the ancient buildings in Europe where borers and death-watch beetles have been active for hundreds of years.

Timber can be made termite-proof by impregnating it with suitable chemicals. There is a wide variety of chemicals from which to choose, ranging from creosote, metallic salts of arsenic, copper and zinc, to chlorinated phenols and hydrocarbons, dissolved as necessary in water, oil or organic solvents. They are forced into the timber by heat, by pressure, by vacuum, or if necessary a combination of these. Cost of treatment in relation to the subsequent use of the timber is the main criterion. For example, creosote cannot be used if the timber is to be painted afterwards; other formulations are suitable for indoor work but quickly leach away if exposed to weathering or soil moisture; for cabinet work cost is of less importance than the ability of treated timber to take on a suitable polish. Depth of penetration is as important as the nature of the chemical employed, within limits. Satisfaction with a brush-on technique which produces so thin a protective layer that a hammer blow will break it is folly, to say the least.

When an existing building is found to be attacked by dry-wood termites, the first step is to ascertain as far as possible the extent of the infestation. Much can be learnt from the little heaps of frass already referred to —their situation, size and rate of replacement —particularly in lofts and below the floor-boards where they are likely to be undisturbed. Some dismantling of woodwork will be inevitable, such as floorboards to inspect the beams, linings of fitted cupboards, and the under-sides of wooden staircases. Cavities in doorposts and the like may be detected by tapping. Machines designed to detect timber borers by amplifying the noises made by the insects when chewing wood have not yet reached a stage of general efficiency that would permit them to be generally recommended for termite work. On the whole there is no doubt that experience is a great asset to the operator, the more in deciding that termites are absent than in producing positive proof of their presence in the form of frass or damaged wood. Timber which is structurally unsafe will be replaced, no doubt, but this *must* be done with a kind that is either naturally resistant to attack or has been made so by efficient impregnation. Non-resistant timber used to repair an infested building will be eaten away far faster than were the original timbers because the termites are now present in large numbers.

Fumigation with, for example, methyl bromide may be successful in ridding a building of all its dry-wood termites if carried out by a qualified operator, who is equipped with the necessary tarpaulins, etc., to maintain a sufficiently high concentration of gas throughout. More easily arranged, but less efficient, is to spray or brush the outer surface of all woodwork with a highly penetrant wood preservative. This will do no more than ensure a shell of sound wood, and kill off any termites which try to reach the exterior for any reason, but it will prevent fresh infestations arriving from outside, so long as the protective layer remains intact—depending on the properties of the solution used and the number of applications. In this way the termites may be held down to a slow rate of increase and the useful life of the building prolonged, providing that the work is carried out honestly and with reasonable skill.

While on the subject of wood preservatives, it may be mentioned that the close association of timber pests with fungus infection applies also to termites. Damp conditions which encourage fungi to attack wood also render the wood more liable to termite attack. Prevention of decay in hardwoods helps to keep termites away. Insecticides which may be extremely deadly to termites in laboratory experiments may have no fungicidal action, and to be of practical value would require to be mixed with other chemicals which would supply the deficiency, while substances not quite so deadly to termites may themselves be fungicides and so prove reasonably efficient in practice as a general preservative.

THE DRY-WOOD TERMITE SITUATION IN EAST AFRICA

So far as our information goes at the moment, there is one kind of domestic dry-wood termite in East Africa, *Cryptotermes dudleyi*. There are a number of wild species throughout the area, including a closely related species *Cryptotermes havilandi*, but these have not been found in the wood-work of buildings. The genus *Cryptotermes* occurs throughout the Tropics but for reasons which are not yet clear it is restricted to coasts. *C. dudleyi* occurs along the East African coast from Malindi in Kenya to Mikindani in Southern Tanganyika, and in the island of Zanzibar, but has not been found inland in places such as Amani and Morogoro. Whether or not the movement of infested timber, in the form of furniture and packing cases will ultimately lead to *dudleyi* getting a foothold further inland cannot be predicted, but with regard to the distribution of the genus as a whole it would seem to be unlikely.

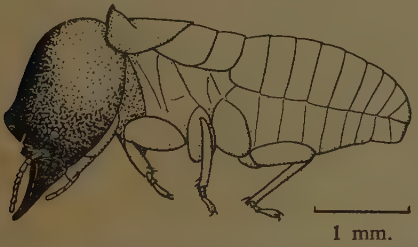


Fig. I.—Cryptotermes dudleyi, soldier, greatly enlarged.

The first published record of a Cryptotermes from East Africa is under the name of *C. havilandi*, by Sjostedt in his Monograph of the African Termites (1925), and one which he had previously described from the Cameroons in 1897. *C. havilandi* is a serious pest of buildings along the West African coastline from the Ivory Coast to the Belgian Congo and there is some doubt about the identity of the East African species which is exclusively "wild" in habit. This question is at present being investigated by Mr. W. Wilkinson, of this Unit. In 1926, termites collected in the ceiling boards of an old house in Dar es Salaam, near the European Hospital, and some years later in the keys of a piano in the same house, were identified as *Cryptotermes havilandi*. This name continued to be used for the termite infesting buildings at the coast, of which there were few records for many years. During the last war, dry-wood termites were found damaging Podocarpus timber in a store in Tanga, and these were ultimately recognized by Dr. A. E. Emerson of Chicago, to whom they were submitted, as being in fact *Cryptotermes dudleyi*. At this time, most of the damage to buildings at the coast and inland until the land rose above 1,500 ft. was done by the subterranean termite *Coptotermes amanii*, whose habit of leaving thin layers of wood inside its workings with spongy masses of pale coloured chewed wood and excrement led to it being popularly called "dry rot". *Coptotermes* damage obscured that done by *Cryptotermes* in its early stages. Then in 1952 it became evident that Mombasa was well infested with dry-wood termites, and cases of damage were found in houses built between the wars, as well as in furniture that was by no means antique. A survey was carried out by Mr. Wilkinson during 1953 to 1955, which established that *C. dudleyi* was present in all the larger towns along the coast, causing damage on quite an extensive scale. The species provisionally referred to *C. havilandi* was restricted to the dead branches of trees. Alone, or in association with *Coptotermes*, *Cryptotermes dudleyi* had caused structural weakness in the main timbers of many of the older buildings, and in addition is appearing in buildings of a more recent origin regarded as being immune from termite attack because of precautions having been taken to prevent subterranean termites from entering the building.

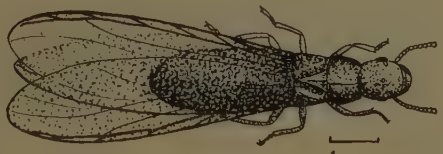


Fig. II.—Cryptotermes dudleyi, winged adult termite, greatly enlarged.

The West Indian dry-wood termite, *Cryptotermes brevis*, of which more is said below, has not yet been discovered in East Africa.

CRYPTOTERMES ELSEWHERE IN THE TROPICS

Cryptotermes dudleyi occurs in Java, Sumatra, New Guinea and in some small islands off the north coast of Australia; in Ceylon, from where it probably came across to East Africa; and in limited areas of Central America.

The most widely distributed and destructive species in the Far East is *Cryptotermes domesticus,* which is found in South China, Formosa, Siam, Malaya, Indonesia and many island groups in the Pacific from the Solomons to Fiji and the Marianas.

Perhaps the best-known species is the West Indian dry-wood termite, *Cryptotermes brevis* whose distribution covers an area from the extreme southern states of the U.S.A., through Central America and the West Indies to the north of South America; westwards to Hawaii and the Marquesa Islands; eastwards to Ascension and St. Helena islands, and the African mainland in Sierra Leone, Boma (Belgian Congo), and the coasts of Natal and Cape Province in the Union of South Africa. In all these localities it is proving a great nuisance, and a serious threat to many buildings.

In general it would be true to say that the rising cost of repairs has focused attention on the damage done by dry-wood termites. In addition there have been certain changes in building design which have made things easier for the termites. Shortage of local hardwoods in many places has led to an increased use of softwoods in buildings, usually without any attempt being made to render the timber resistant by means of impregnation with suitable preservatives. Sometimes, too, it can be seen that timbers of much reduced dimensions are employed in an effort to reduce expense, which greatly reduces the amount of damage that can be done by wood-eating insects before the structure becomes unsound. The installation of air-conditioning units in the Far East has frequently led to softwoods and wallboards being used in older buildings whose hardwoods had hitherto successfully resisted termite attack. Finally it would seem that even the best of timbers begin to loose resistance to termites in 40 to 50 years, and an increasing number of buildings are approaching the danger line, and termite damage is being observed in them for the first time.

REVIEW

GARDENING IN EAST AFRICA. A practical handbook, fourth edition, edited by A. J. Jex-Blake. 414 pp., 23 plates, published by Longmans Green and Company, London, 1957, price 45s.

The new edition of this well-known book, which is written by members of the Royal Kenya Horticultural Society and of the Kenya, Uganda and Tanganyika Civil Services, has been much improved by the rewriting of five of the chapters; those on climate, elementary horticulture, the propagation of plants, exotic orchids, and insect pests of the garden. Most of the other chapters have been revised in the light of recent experience, and although the book is not much larger than the third edition, it is more comprehensive and up to date. Particular praise must be given to the plates, which are outstanding in their clarity and colour; most of these have been redrawn in such a manner that identification is greatly simplified.

The chapters on elementary horticulture and on the propagation of plants deserve special mention for their practical value, but the book is a compendium of knowledge for gardening in the high-altitude tropics and in the subtropics. The chapter on gardening in Tanganyika deals with lower altitude, dry areas, while that on gardening in Uganda selects the most suitable plants for wetter and warmer districts. Two chapters on fruit growing supply much-needed advice on the home orchard, both in the Highlands and on the coast, and the chapter on vegetable growing is so clear that even a beginner could maintain a varied supply of vegetables throughout the year. The book can be highly recommended to all who are interested in gardening in East Africa and in similar climates.

P.J.D.

PROBLEMS OF INCREASING LIVESTOCK PRODUCTIVITY IN THE INTENSIVE FARMING AREAS OF UGANDA

By D. J. Parsons, Department of Agriculture, Uganda

(*Paper read at the Veterinary Staff Conference, Entebbe, on* 13*th March*, 1957)

The present position as to livestock productivity in this country is well known to all here. The systems of cattle-keeping may vary in detail from district to district but in the main throughout the country cattle are completely divorced from the arable land and are looked upon by their owners as a bank from which cash can be drawn when required (by sales) and as a means of enabling their sons to marry. Under these conditions beef is in reality a product of a ranching system and, as such, returns of cash per acre of land utilized are extremely low. In certain areas, particularly in the environs of the larger towns of the Protectorate, a certain amount of milk is produced, but in most cases this milk is also a product of the grazing of common lands and swamps, and the cattle supplying the milk are not very often managed as a part of the man's farm or holding. However, where milk is produced the returns per acre of land utilized may well be greater than in the case of beef production.

In order to bring about a more responsible attitude to land and production among the African farmers of Uganda, this Department has recently started a farm-planning service which, as envisaged by the Royal Commission, would tackle the two most important limiting factors of African agricultural production, that is the maintenance of fertility by the ensuring of an adequate resting period in arable rotations and the integration of stock with the land. As we interpret our responsibilities, this leads to an enclosure movement with the purpose of producing farmers rather than cultivators, and includes not only the systematization of arable farming but also the integration of stock to produce a true system of mixed farming and, most important, the planning of farming operations on an economic basis. It is perhaps needless to add that as population grows and land area remains static the only outlet for the men who are gradually being squeezed off the land will be industry. If you carry this process to its logical conclusion you arrive at the position of a mature community such as England today where the land is owned by a few large farmers rather than by millions of subsistence cultivators. These large farmers of the future are the men with whom the Farm Planning service is concerned, as we are planning for the future as well as for the present. It is in these large enclosed farms that I am interested rather than in the thousands of cultivators all owning cattle and dependent upon commons for their upkeep. If I may, therefore, I would like to study the problems of livestock productivity on such farms, as it is here that we first come into contact with the realities of livestock productivity.

The problems of livestock productivity in the farm planning service can almost entirely be classed as economic. Most of the areas with which we will be concerned are cattle areas. We are initially dealing with applications for planning from the larger farmers, many of whom own large herds and land measuring between 30 and 300 acres. We consider that in each district it is advisable initially to confine our planning to a dozen such farmers in order that follow-up work may be adequate.

When planning a man's farm and considering stock production as a project on that farm we must plan so that the maximum returns per acre are obtained from the leys and rough grazings contained within that farm boundary. In the first instance, we must also work on the basis of the farmer's existing stock, and in this paper I will consider the Zebu stock of our Eastern and Northern Provinces. The first problem to be solved is what form this production is to take, beef or milk. Let us consider the relative productivity of these two forms of production on a return of cash per acre per annum basis.

First, *stocking rate*.—Although it may be possible to work in some areas on a basis of one beast per acre of ley grass and one beast to two or three acres of rough grazing, I think you will agree that on most of the farms we are dealing with, these rates are optimistic, at least for a start. Let us then base our figures on a stocking rate of one young beast (up to 500 lb.) to two acres and one mature beast to three acres over ley and rough grazing alike.

Secondly, *rate of live-weight increase.*—From figures of live-weight increase of male stock obtained from Serere, and Kenya, it would appear that, in herds which are well managed throughout, the live-weight increases vary only slightly from 12 months of age until 42 months, after which they drop, although at Entebbe they appear to remain steady up till five years of age. The six-monthly increases from 12 months to 42 months average 82 lb., i.e., about 0.46 lb. p.h.p.d.

On this basis if we run a beast from 12 months to 42 months he will need two acres per year from 12 months to 30 months and three acres per year from 30 months to 42 months of age. Let us say that over this period he will have utilized the grazing off an average of 2½ acres per year. During this time the beast will have gained some 400 lb. liveweight. Therefore, 2½ acres for 2½ years has produced 400 lb. live-weight. When killed out this will yield about 200 lb. of beef, or 32 lb. beef per acre per year only. If run on for a further year as the Entebbe figures would justify, a larger beast would be marketed but the overall profits per acre would not alter materially.

At the Teso local price of Sh. 1/30 lb. beef, this system of running bullocks from 12 months to 42 months, therefore, produces Sh. 40/80 per acre per year, or Sh. 46/40 including the hide, which is a very poor return.

Under Teso conditions there is an alternative method of producing beef. In the case of most of the larger farmers the number of stock owned is such that the carrying capacity of the enclosed farm is not sufficient to accommodate the whole herd. Under these circumstances, it is possible to draft in stock in store condition from the ranged herd and utilize the enclosed leys and permanent grazing for fattening up to market weight. Under these circumstances the live-weight figures from Entebbe and Serere cannot be used directly, as the growth curves of stocks brought in in store condition and fattened on good grazing will not correspond to the curves obtained from stock maintained on a uniformly high level of environment throughout their life. We may surmise that under these conditions a live-weight increase of 0.5 lb. per head per day is as much as can be expected. Similarly we may extend the period of profitable live-weight increase until four years of age or more. Therefore, although we have no figures as yet to base the optimum ages of running stores on a farm for fattening, let us consider the returns per acre possible from bringing in animals at two years and running them on the farm for two years, selling off at four years old. At two years old a beast in store condition may weigh 300 lb. At an estimated gain of 0.5 lb. per day it would weigh 665 lb. at four years old. This gives us at 55 per cent killing outturn 200 lb. of beef over two years. Based on the same stocking rate and price of beef as before, we have a return of Sh. 52/-, or Sh. 58/- including the hide, per acre per year gross, which is slightly more than the rearing system but still not very great. Where milk markets are unobtainable this is probably the best that can be done. In addition we must bear in mind the fact that grass at the moment on the farm produces nothing, and grazing leys should result in higher production in the subsequent arable period.

Compared with these returns from beef production let us now consider what sort of returns can be expected from milk production. The overriding problems of milk production are (1) the capacity of the local cow to produce milk surplus to the calf and family requirements and (2) the establishment of milk markets. However, if we consider these later, let us base our workings on a unit of 100 gal. of milk sold per year per cow.

The minimum price of milk per gallon will be 80 cts. when sold for ghee. Where a fresh milk market is available Sh. 4/- per gallon to the producer is not unrealistic. At a stocking rate of one beast to three acres to carry the milking cow and her calf up to weaning, and supposing the cow to produce 100 gal. of milk for sale each year, this gives us a figure of Sh. 27/- gross per acre per year as ghee, or, alternatively, Sh. 133/- gross per acre per year as fresh milk. The costs of production of milk are likely to be higher than that of beef, but the income from the beast ultimately sold as beef will contribute slightly to the profits.

No one, I think would seriously consider starting a dairy industry with any hopes of making a fortune on cows yielding 100 gal. only. When we consider milk production on a basis of 200, 300, 400, or even 500 gal. surplus per cow, however, it is obvious that milk will prove far more profitable than beef production. Unfortunately, when planning a farm on the ground we have to deal with facts as they are, and the hard fact is that with the cattle available, even under good management, it appears most unlikely that even 100 gal. will be produced as surplus to calf and family requirements. This supposition may be supported from the Mbarara Zebu figures of milk production (50 to 70 gal. average). On once-a-day milking the Serere average is well below 200 gal. and the Kenya figures of Zebu production of stock which have been highly selected for 20 to 25 years average 244 gal. milked out, which may be translated in terms of once-a-day milking to a surplus of about 134 gal. Ngetta averages 3.5 lb. per day per head for 200 days. This emphasizes the necessity for the improvement of local stock, but before I broach this subject I would like to examine the possible methods of milk production open on a planned farm.

I myself prefer the system of once-a-day milking with the calf running at foot during the day. Under this system admittedly only about 55 per cent of the milk is obtained but a calf is reared well. The alternatives are twice-a-day milking with the calf at foot and/or two-teat-milking, and milking out twice-a-day with the calves bucket-fed. This latter system I do not consider applicable, nor yet even desirable, at present. Apart from the very much greater labour and capital input necessary it may well prove impossible to feed the calf properly on the milk provided by the cow. It is doubtful if milk let down without the calf could be obtained on these farms. I feel also that without proper supervision this system is doomed to failure. The purchasing of milk substitutes or the purchase or even growing of concentrates for the calves would certainly prove uneconomic unless milk yields of a high order were obtainable. The other alternative, i.e., milking twice-a-day with a calf at foot, has been tried at Serere and was rejected due to the difficulty of seeing that the calf received sufficient nourishment. However this may possibly prove a suitable system if milk were the main project and the calf valueless. This is not the case on our mixed farms where future milkers and oxen for beef or work must be well reared.

Now as to the improvement of the local stock. Let us acknowledge right away that unless the existing stock are improved there is no future for stock projects on a profit-making farm. At the moment, on nearly all our farms the farmer owns stock and, therefore, stock will be kept even if only for their draught and manure. However, unless something more than the Sh. 50/- an acre gross mentioned above can be produced, the only justification for the application of any capital to the project is the prospect of increased crop yields. It may be economic to purchase seeds for leys, but this is doubtful and will depend on circumstances. From the point of view of crop improvement it may be justifiable to fence for night paddocking. Therefore, I maintain that the existing local stock must be improved. We of the Agriculture and Veterinary Departments have in the past maintained that to improve the indigenous cattle by selective breeding is the optimum method of tackling the problem. With this policy I was at one time in full agreement. Everyone concerned has agreed that this course was of necessity a slow one. Now, however, events have caught up with us. We have not local stock of good performance in any numbers. I am now planning farms and have not the means at my disposal to help a farmer increase his stock productivity by purchase of high yielding stock. That is the big problem of livestock productivity as far as I am concerned. I am sure that it is now time to admit that the policy of breeding up indigenous Zebu stock has failed. A hostile environment for hundreds of years has exerted high selection pressure against any form of production, and nature has now left us with the scrapings of the barrel—only those beasts with the least productive potential have survived. To breed up these is indeed a long-term policy. I firmly believe that our answer now for quick results is the importation of exotic stock or semen or both.

It may be of interest to estimate the money that could be made if good milking cattle were available to farmers in this country. Based on the figures used previously in this paper, if a farmer owned stock giving him 500 gallons of surplus milk for sale (some of the best Kenya Sahiwal x Zebu half-breeds have yielded 700 gal. and Mr. Marples has produced a 600-gallon Nganda cow), then selling at the ghee price of 80 cts. per gallon the farmer would obtain Sh. 133/- per acre per annum from his grass, and on a fresh-milk market a return of Sh. 677/- per acre would accrue, which compares well with gross returns of perhaps Sh. 300/- per acre for a well-grown cotton crop.

I do not think it possible even with the improvement of our existing stock by the importation of exotic blood to obtain a comparable return from beef production. Wherever possible, then, we think in terms of milk as the better animal product to go for on a planned farm if the stock are capable of producing a surplus. However, the marketing of milk is another problem. At the start of our planning in any district it is difficult to establish a market for small quantities. Existing dairies can sometimes help but usually the establishment of a ghee centre in a planning area will probably be all that can be managed. In due course co-operatives may well be able to handle milk and butter as they do cotton today.

I would like now to tell you of a specific instance of planning the first farm in Teso, which I did recently. Here the farmer had two farms, one of 30 acres and one of 170 acres. On the larger farm there were six relatives with families settled and cultivating in addition to the farmer's cultivation. The farmer owned 40 head of stock. We decided quite early on in the deliberations that the presence of six relatives on the larger farm made planning impossible, and undesirable, if we were to endeavour to keep any track at all of the profitability of the farms to the farmer. We decided then to plan the 30-acre farm and a block on the larger farm which the farmer would farm himself. This was ruled out as he did not want to apportion a definite area of his 170-acre farm for himself in case the relatives then laid claim to the remainder. We had now to consider only his 30 acres and regard the 170-acre farm merely as part of the rough grazings open to all and this would not be planned. (These two farms were very close.)

We, therefore, started discussions with the farmer on how he should make profits from his stock. We suggested selecting a few of his best milking cows to be kept in the 30 acres while the rest of his cattle grazed the larger farm. His objections were two-fold: firstly the selling of the milk. He did not consider a price for ghee of 10 cts. per pint of any use to him, taking into consideration the small amount of milk he was likely to obtain. We had perforce to agree. Secondly, he pointed out that to split his herd thus would mean he would have to take on a second herdsman as we were unable to assure him that the cost of perimeter fencing his farm would be justified. We then suggested beef production and explained the system of running stores on his 30-acre holding. The objection of a second herdsman was once again brought forward. (It must be realized that on this farm all the labour force were relatives working for beer or a chicken or the loan of a plough, and outside paid labour was not only difficult to obtain but very unpopular.) After considerable thought and discussion we came to the conclusion that in fact the only use this farmer could obtain from his stock was their ability to produce manure—from this we could improve production by increasing crop yields by means of a night-paddocking programme.

It seems to me we will find this position in most of the farms we visit and it only goes to point the assertion I made previously that unless the indigenous stock are vastly improved there is no place for them on a profit-making enclosed farm. They are in their present condition fit only for a system of ranching, utilizing land which cannot for one reason or another produce crops. This is in fact how they are being utilized and the returns obtained from them are abysmally low. In saying this I am fully aware that the second largest cash project in Teso is cattle sales.

However, this is not the end of the story of our first planned farmer. He then made the suggestion that he should link his cattle-trading business to his planned farm. It had appeared as a result of our questioning that he had 40 head of cattle. However, this just happened to be the number he had on the farms on that day. It transpired that he keeps £100 as a trading fund and purchases cattle locally from farmers requiring ready cash each month. These cattle usually number three to six beasts and use the farm as a resting place before being walked to Kumi or Bukedea markets for re-sale. The beasts stay on the farm usually for one month or until the next market. If a good price is not obtained they are returned so that the cattle population on the farm varies considerably. He usually sells them for Sh. 100/- more than they cost him. If he only buys and sells three animals a month his net profit on this project would be £180 per annum and these are quick returns. He also maintains a herd all the year round on his farm for family milk and draught requirements.

We finally decided that it was well in line with what we had been preaching on farm planning, i.e. that plans should not be stereotyped and that the farmers' individual preferences should always be considered, to incorporate this project as part of the farm plan. Finally, therefore, we laid out a system of blocking for crops and leys on the 30 acres and arranged for all beasts to be night-paddocked on these leys, utilizing the rough grazings for daytime keep. In this way, in addition to his trading profits, the increment in crop yields due to the night-paddocking of a large number of beasts on a five-acre block each year should prove to be considerable. In this rather tortuous fashion, and only in this way, were we able to find a profitable means of livestock keeping for this farmer and a means by which his stock will contribute considerably to additional production of crops.

REVIEW

THE STUDY OF THE SOIL IN THE FIELD, Fourth Edition, by G. R. Clarke, published by the Clarendon Press, Oxford University Press, 1957. 204 pp. Price 35s.

Natural soil comprises a continuous variant, and division into taxonomic units must always be somewhat arbitrary, partly due to the need to select a prescribed range of otherwise overlapping properties. The difficult task of evolving a common system of soil classification at different levels would be eased by the adoption of a uniform and a more complete system of describing soil-site and soil-profile characteristics. The book under review, revised after an interval of 16 years, has been expanded to incorporate new developments in the study of soils, and the suggested detailed systematic methods of observing and recording the properties of soils in their natural environment should make for greater uniformity in their description and classification.

The author discusses the interaction of climate, parent material, relief, mode of formation, drainage and vegetation. It is of special interest to East African readers that he also takes note of the role of the age and history of the land surface and of catenary conditions in relation to soils and their distribution. Some 70 pages are devoted to the study of the wide range of soil properties that can be noted in specially prepared representative soil pits, and systematic methods of recording these properties are given in some detail. The first task is to separate out the soil profile, as far as possible, into natural horizons which show up differences in soil morphology. Soil workers in East Africa who have long been puzzled by the multiplicity of soil horizons—some involving several subdivisions of the usual A-B-C horizons—which are recorded in the literature will appreciate the comment that "most tropical soils do not have horizons at all comparable with those for which the common A-B-C terminology was developed".

The observations recorded separately for the different horizons—or for more simple divisions of the soil profile where pedological horizons are not apparent—deal with soil colour soil texture, soil constitution and soil structure: the latter important soil property is dealt with in great detail and several different systems of structure classification now in use are described. Similarly, suggestions are offered for the systematic recording of observations on root development, the kind and distribution of organic matter, soil drainage conditions, secondary chemical deposits, and the effects of soil fauna on the soil profile. Full details are given of the special field technique for taking soil monoliths to serve as permanent records of particular pedological processes. Accompanying photographs show up different kinds of soil structure and constitution. The new edition includes a chapter of some 30 pages on the use of photographs as aids to soil surveys, and examples of photo interpretation are given on transparent overlays. Finally, the principles of several systems of soil classification and mapping are given, including some which have been evolved for the evaluation of the agricultural properties of land. Although the methods advocated are too precise and detailed for general use in underdeveloped countries, the principle of a systematic study of soil-site and soil-profile characteristics remains. Frequency and amount of observations taken can be reduced and field technique modified to give more rapid, broader surveys of large tracts of land.

The main appeal of the book is as a useful text-book for the study of soils in their natural environment by soil scientists in general and also their associates to whom some knowledge of this subject is desirable. It serves as a manual for pedologists concerned with a precise, adequate and uniform presentation of objective observations aiming at a more rational system of describing, classifying and mapping soils. G.H.G.J.

TREE-PLANTING TRIALS FOR THE CONTROL OF THE RED LOCUST (NEMADACRIS SEPTEMFASCIATA) IN THE RUKWA VALLEY, TANGANYIKA

By Ian A. D. Robertson, International Red Locust Control Service, Abercorn, Northern Rhodesia

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It will be realized that in any attempt to control a pest of such considerable economic importance as the red locust (*Nomadacris septemfasciata* (Serville)), all avenues which may lead to some measure of success must be explored. It has been noticed by several writers (Lea, 1938; Michelmore, 1947) that when red locusts are found in any numbers, apart from where they are actually moving as swarms, they are always associated with permanent grasslands, particularly those which tend to become seasonal swamps. They are never found in forests, or even open woodland, and it has been noted that in the outbreak areas, when there are scattered trees there are usually few locusts.

At the Fifth International Locust Conference at Brussels in 1938, Senhor A. C. Saraiva, a member of the Portuguese delegation from Mozambique, suggested that ecological control should be tried in the outbreak areas, and that trees might offer a feasible solution. A resolution (Resolution 9) was therefore passed by the Conference that "The Conference considers that the method of controlling *Nomadacris septemfasciata* by the afforestation of its outbreak centres offers considerable theoretical advantages and should be tested in practice". There the matter rested until in 1951 when Dr. D. L. Gunn, Director-elect of the International Red Locust Control Service, after consultation with authorities on tropical trees, in London, Oxford and elsewhere, came to the conclusion that not enough was known to enable the International Red Locust Control Service to obtain their requirements by stating the physical and chemical conditions in the habitat. Therefore, encouraged by the success of Eggling (1935) in Uganda and Duff in Northern Rhodesia, in growing *Eucalyptus* in swamps, it was decided to start trial tree plots in the Rukwa Valley outbreak region, in the open grassland, with the object of finding out whether it would be possible to establish trees in the grassland and, if so, what effect they would have on the locust population and what effect the locusts would have on the trees.

It was realized that the causes of the observed correlation between presence of trees and absence of red locusts were entirely unknown. The fact might be that the red locusts required certain soils and other habitat factors in such a combination that would normally prevent tree growth. In that case, artificially assisting trees to grow would not affect the locusts. It could also be held that, as trees do not grow naturally on the plains, they cannot be made to do so. What prevents their growth was not clearly known, but it was conceivable that there was one unfavourable feature which could be neutralized. It was envisaged, however, that, if trees could be established they might affect the locusts in several ways. Their presence might be favourable to many locust predators, mainly birds, and they might have some effect on locust behaviour. Also, indirectly, the presence of trees would mean that they would alter the ecological conditions in the valley, or at least round themselves probably to the disadvantage of the locusts. These trials were begun in 1952 at Kafukola Research Station in Central Rukwa.

It was considered that if trees could be grown on the grassland, they could be made to fulfil several very useful and important functions, apart from the possibility that they might produce some depressing effect on the locust population. They could be used, planted in a wide grid, as landmarks, the plains being flat and in many places completely featureless, which makes the rediscovery of particular places very difficult. They could be used as strips to help define the various smaller areas within the large plains, and, if suitable species could be induced to grow, they could be used to form permanent firebreaks.

THE RUKWA VALLEY

The Rukwa Valley lies between latitudes 7° and 9° South and longitudes 31° and 33° East. It is approximately 200 miles long and 40 miles wide, and is a closed valley having no outlet and being completely surrounded by an escarpment which varies in height from 300 to 3,000 ft. The valley is orientated N.W.–S.E. and the floor of the valley is 2,600 ft. above sea level. Lake Rukwa lies in the southern half of the valley and is approximately 80 miles long; it varies in width from 5 to 35 miles. It is a shallow alkaline lake, the water level varying considerably according to the rainfall in the drainage area; in some years the northern half may be completely dry. Fringing the foot of the escarpment is a belt of forest, which varies in depth from 5 to 20 miles, and between the forest and the lake lie the grass plains which support the red locust population. The locust grasslands of the Rukwa Valley total some 1,000 square miles, and Central Rukwa alone, where the tree-planting trials were carried out, is about 550 square miles in extent.

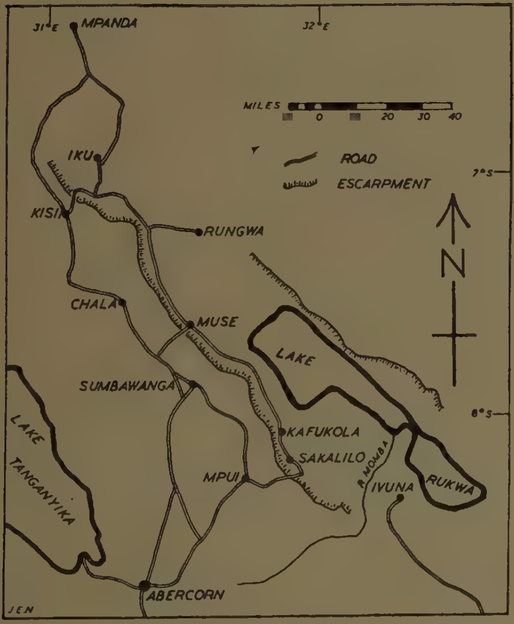

FIG. I. MAP OF THE RUKWA AREA

The fringing forest is characterized by the following tree species: *Acacia polycantha* sub-sp. *campylacantha, Acacia tortilis, Acacia xanthophloea, Ficus sycamorus, Chlorophora excelsa, Lonchocarpus capassa, Tamarindus indica, Sterculia quinqueloba, Adansonia digitata, Kigelia aethiopica, Piliostigma thonningii, Combretum* spp., *Pterocarpus angolensis, Brachystegia* spp., *and Commiphora* spp. The co-dominant grasses in the fringing forest are *Panicum maximum, Digitaria milanjiana,* and *Hyparrhenia gracilescens.* In the fringing forest are many native villages and many crops, including maize, finger millet, cassava, sweet potatoes, groundnuts, beans, pumpkins, bananas, mangoes, and kapok, with, in the swampy areas formed by the rivers coming down the escarpment, rice and sugar-cane. The colluvial soil of this fringing forest is very fertile and many crops could be grown there. During the tree-planting trials many of the trees planted within the forest edge survived better and grew much more rapidly than those planted on the grassland. Cattle, sheep and goats are also kept by the villagers, but it is to be noted that they are very seldom taken out of the forest to graze on the grassland.

The Central Rukwa grasslands are dominated by the following species of grass: *Echinochloa pyramidalis, Hyparrhenia rufa, Sporobolus robustus, Diplachne fusca, Cynodon dactylon, Chloris gayana* and *Cyperus longus.* Except for *Cyperus longus* all these species appear in very extensive pure stands, as well as mixed together. Running through the very flat plains are several water channels, which run roughly parallel in a N.E.-S.W. direction. In the wet season the plains tend to become flooded, and in the dry season they tend to become very dry and arid, most of the area usually being burnt in August or September. The grassland supports a large number of game animals, and the I.R.L.C.S. in collaboration with the Tanganyika Veterinary Department have now established an experimental herd of cattle on the plains in an attempt to discover whether cattle ranching could be an economic proposition.

There are several theories about the status of the Rukwa grasslands. It may be that they are a fire climax, caused by the fierce fires which swept across the plains each year, or it may be that is an edaphic climax caused by the build-up of alkalinity in the soil through changes in lake level. Some scattered trees do survive on the plains and there are tongues of trees following some of the main watercourses, but in general the line between the forest and the plains is very marked, and suggests a drastic edaphic change. It may be correct to say that both the factors of fire and soil are involved with varying importance in different areas of the plains.

The rainfall in the valley is very erratic, and during the years in which these trials were carried out, the average rainfall varied from 25 to 40 in. The rainy season lasts from

November to April, the rest of the year being completely dry. Due to the type of soil, and the fact that there is no outlet from the valley, the plains tend to flood extensively during the wet season, sometimes to a depth of several inches and sometimes for up to three or four months per year. This flooding is one of the main problems of tree planting in the Rukwa. It is considered that the flooding may be caused by three things:—

(1) Flooding from local rains, which appears to be partly caused by the fact that the black surface soil swells when wet and becomes fairly impermeable; the excess water is then only slowly absorbed.

(2) Fresh water flooding caused by water overflowing from the river channels which, the valley floor being very flat, have little flow and so become severely choked with grass. Much of this water is carried down the escarpments.

(3) Brackish water flooding caused by a rise in lake level. This again is mostly caused by water coming from outside the valley down the four main rivers, Rungwa, Kavuu, Momba and Songwe.

The flooding, which depends on the rainfall both inside and outside the valley, is very variable. It may be extremely local and of short duration, or it may be extensive, persisting for several months. There is historical evidence of flooding lasting for several years. The areas in which the experimental tree planting was done, were areas of fresh-water flooding, in which the ground does not often become more than waterlogged.

The dry season in the Rukwa is very severe, and must be regarded as an important factor limiting the possibility of tree growth. The rains stop in April, and some surface water usually remains available until June, or even longer. Also this is the coolest season of the year, so that tree seedlings have a reasonable chance of survival for this period. By August, however, most of the surface water has usually disappeared, and it is often necessary to transport water for long distances to supply locust personnel living in the plains. In October it becomes very arid, and the maximum shade temperature may reach 105° F. The soil forms a very hard crust, especially where water had been lying in the wet season, and in many places begins to crack very badly, the cracks sometimes being several feet deep. Any attempt to cultivate soil during the dry season leads to the breaking up of the surface crust, much of which is reduced to small, hard particles and powder. To add to the effect of the drought is the fact that when the very heavy grass cover dries off, by about August, fierce and widespread grass fires sweep across the plains. These fires, apart from greatly increasing the drought effect, must be considered in themselves as a great hazard to tree growth. Seeds and seedlings in the ground are destroyed, and even adult trees, unless they are fire-resistant species, must be carefully fire-protected if they are to survive.

In general, the soils in the Rukwa appear to be similar to the black cotton soils usually found in *'mbugas,* with the addition that, being in an enclosed valley, there is a continual build-up of salt deposits. The soil consists of a black surface layer which varies in depth from 6 in. to several feet, and a very deep lower layer consisting of almost white silty clay. This soil becomes hard and cracks very badly in the dry season and becomes very heavy, wet and plastic in the wet season. Very few soil analyses have been done, but what data we have suggests that the chemical composition of the soil is such as to make the ground rather unsuitable for many species of trees. The pH ranges from 7.4 to 10.7, with a very high conductivity (500–2,400), which indicates saline conditions. Free calcium carbonate is usually present and in most places in the valley the well water is saline.

TREE-PLANTING TRIALS

Choice of Species

From the details noted above, it will be seen that the conditions for tree growth are very severe indeed. As I have mentioned, there are some scattered trees surviving on the plains, and it seems likely, from the results of fire protection plots, that local species could be encouraged to extend outwards from the forest edge if fire could be completely excluded. The danger from fire here seems to be mainly to the seeds and seedlings, as there are also fires in the forest, which well-grown trees can resist; the fires sweeping the plains often tend to be fiercer and to produce a much cleaner burn than those in the forest. In general, from the fact that very few local trees seemed to be able to establish themselves in the plains, it was decided that the best thing would be to attempt to find exotic species which might survive the Rukwa conditions, while also attempting to rear whatever local species showed signs of success. Accordingly, the advice of the Northern Rhodesian and East

African Forestry Departments was asked, and we met with great kindness and interest. It was recognized that this was a problem outside the normal run of forestry work, and one in which there was no detailed knowledge of the actual conditions which the trees would have to withstand. When asking for suggestions we were able to stipulate the temperature range and rainfall in the valley, and were also able to give some details of flooding, drought and soil conditions. Some of the suggested species were remarked upon as being very doubtful or of being of no commercial value, but, as our primary object was locust control, it was decided that, if seeds could be obtained, anything was worth a trial. Information on *Eucalyptus* was finally sought direct from Australia, in the hope that some species hitherto unknown in Africa might be suggested. Our inquiries were received with marked interest and immediate co-operation but, unfortunately, it has not been possible to date to give any of the suggested species a proper trial.

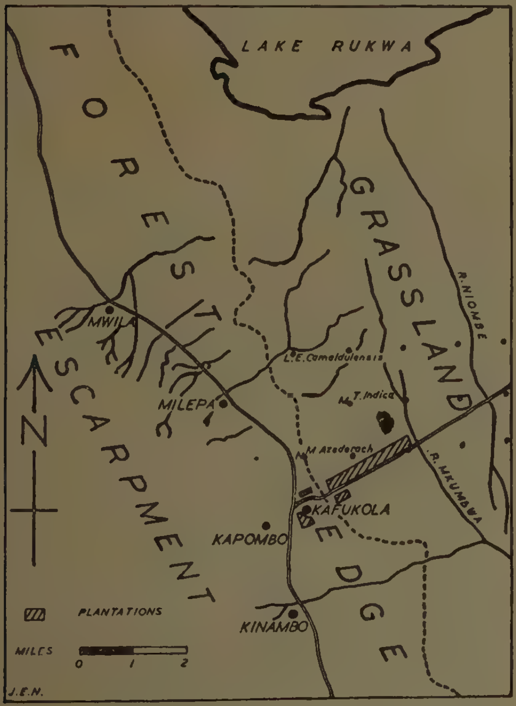

FIG. 2. THE EXPERIMENTAL SITE

Planting Techniques and Results

With the advice on suitable species, we received very valuable advice on planting and nursery techniques. There can be no doubt that during the first two years the trials suffered greatly from lack of knowledge of technique, and that the greater success achieved in the last two years has been at least partly due to the fact that the Tanganyika Forest Department was able to post an African Forest Guard to work at Kafukola.

The three main methods of planting suggested, were spot sowing, mound planting and ridge planting. The idea of spot sowing directly in the plains was abandoned because of the type of soil, powdery when dry and rapidly waterlogged when wet. Also the grass grows so rapidly in the rainy season that the seedlings would very likely be killed by the competition. Both mound and ridge planting have been tried in rather modified form, and ridge planting has been found to be the more successful; mounds tending to dry out very badly in the dry season. The method of ridging adopted was to cut a furrow with a three-disc plough during the dry season, and then plant the seedlings at the beginning of the rains, on the ridge formed. In the rains the furrow tends to act as a drain.

One of the criteria of the trials was that any trees established in the plains should be able to survive with a minimum of attention. The seeds and seedlings were attended as well as possible when they were in the nursery, but, after they were planted out, attention had to be restricted to fire protection of the plot, a first essential, and some cultivation round the seedlings. The cultivation round the seedlings was regarded as being of great importance, as the grass growth in the Rukwa is very rapid and the grass roots make very serious competition for the tree seedlings. Accordingly, an area some 10 ft. in diameter was cleared round each seedling, and the seedlings were heavily mulched with dry grass. Several times throughout the year the surface of this clear area was cultivated to avoid caking of the surface during the wet season and the lethal cracking of the soil in the dry season.

Details of the numbers of trees planted in the plains and numbers surviving are not given, but during 1953 and 1954 results were very discouraging. The most successful species were *Melia azederach* and *Tamarindus indica.*

In March, 1955, the Forest Guard started work at Kafukola and, from then on, it was possible to keep rather more detailed records of the trials. In general, the method adopted was that seeds were planted in beds in the Kafukola nursery in June and July, and when they had reached a suitable size, they were transplanted into banana leaf pots. When the rains came and the ground was reasonably wet, these banana leaf pots were then planted directly into the ground. This method of transplanting was found to be very satisfactory, as the use of the pots ensured that the root systems were not seriously disturbed during transplanting, and also ensured that the seedlings were not planted too deeply in the ground, a common fault among the labourers used for planting.

In both 1955 and 1956 a considerable number of species either failed to germinate or the seedlings failed to develop. In 1955 there was a rat plague in the valley, and such seeds as *Maesopsis eminii* and *Melia azederach* were all dug up by the rats within a day of being planted. The rats also destroyed many of the young seedlings and, on one occasion, a number of chickens got into the nursery and did quite a lot of damage before they were discovered. In 1956, seeds of *Eucalyptus sideroxylon, Eucalyptus astringens, Eucalyptus populifolia, Eucalyptus crebra, Eucalyptus melliodora, Eucalyptus bicostata* and *Eucalyptus robusta,* all of which had been received direct from Australia, were sown in the nursery. All the species germinated quite quickly, but within a month, all the seedlings died.

Bombax rhodognaphalon persistently failed in the plains. In each year the seedlings grew vigorously until the middle of the dry season, then as soon as the water became scarce they died. Their death was accelerated by the fact that their bark and leaves were severely attacked by rodents and orthoptera. All the species of trees in the plains are used at night as roosting sites by locusts and grass hoppers, and all suffer damage to some extent. *Cassia siamea* also suffers severely from defoliation by a leaf-cutter bee. Another hazard is that the seedlings are much used for perching during the day by birds and this results in frail branches being broken.

The considerable success, relative to previous years, achieved in 1955–56 may partly be attributed to improved techniques, but I consider that the main reason is the fact that in 1955 the rainfall was approximately 10 in. higher (40 in.) than it had been previously. This meant that the water table was considerably raised, and the roots did not have to penetrate the soil for any great distance before finding sufficient water. Growth rates in the surviving trees have been rapid. *Eucalyptus maculata, E. rostrata, E. camaldulensis** and *E. robusta* planted in December, 1955, now at the time of writing (February, 1957) range from 6 ft. to 12 ft. in height.

It is considered that the most successful species so far found is *Melia azederach* (Persian Lilac). Seedlings planted in 1954 have the following history: planted in the Tanganyika Forest Department nursery, Mbeya, in June, 1954; transported by lorry from Mbeya to the Rukwa, a distance of some 350 miles over rough roads, in December, 1954, and planted out in the plains at the beginning of March, 1955, just near the end of the rainy season. They had little time to become established before the dry season began and, as might be expected, a great proportion of them died. The survivors, however, withstood the dry season very well and, with the coming of the 1955–1956 rainy season, began to grow very rapidly. Now, February, 1957, they are approximately 12 ft. high and are of strong form; they are now flowering and seeding for the first time.

Plate I.—Persian lilac (Melia azedarach Linn) in July, 1956, 25 months after sowing the seed. Planting out had to be done very late in the wet season (March, 1955), but the surviving trees did well and have since flowered (1956-57). The two men are both six-footers.

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* *E. rostrata* and *E. camaldulensis* are synonymous names.

Tamarindus indica have proved to be reasonably successful, but they are slow-growing trees, and on the plains are developing very slowly, presumably because soil conditions are far from optimal. One very obvious fact throughout the trials has been that trees planted at Kafukola Camp, within the forest edge, and only some half a mile from the plots in the plains, grow much more rapidly. Also a far greater proportion of them survive. It is considered that this points to the likelihood that the soil condition in the plains is the limiting factor for tree growth.

In January, 1956, a trial was made of ploughing up an area on the plains, and sowing seeds directly in the cultivated ground. The following species were sown: *Eucalyptus camaldulensis, Eucalyptus robusta, Eucalyptus citriodora, Tamarindus indica, Leucaena glauca, Acacia arabica, Afzelia quanzensis* and *Melia azederach.* All these species germinated, although not very successfully, but all the seedlings had died by the end of February. It is assumed that the reasons for their death were waterlogging of the soil, and the very severe competition from the grass seedlings growing with them. At the same time 500 cuttings of *Euphorbia tirucalli* were planted. It was suggested that this succulent, if it could be induced to grow in the plains, could be used to form firebreaks. The trials, however, were unsuccessful and again it is considered that the most likely reason for the failure was the waterlogging of the soil.

In August, 1956, a fierce grass fire entered an area which had been protected from fire for two years. Situated in this area was a plot containing 606 *Eucalyptus rostrata* seedlings planted out in December, 1955. Because of the fire protection, there was a rather dense mat of debris under the seedlings and the fire, when it entered the plot, was beyond all possibility of control. At that time the seedlings were about 3 ft. high; after the fire, only the stems remained, and they appeared to be quite dead. Within a month, however, new shoots had begun to appear from ground level, and now about 150 are regenerating. This was very interesting as it shows that, although a maximum effort must be made to keep fire out of the plantations, it is possible to get regeneration with *Eucalyptus* seedlings which are only about a year old.

In Central Rukwa a square mile grid of numbered marker posts is being set up, to facilitate the pinpointing of locust concentrations for control. As a culmination to the tree-planting trials, three lines of seedlings were planted in December, 1956, following three of the marker lines, from west to east, across the valley. Three seedlings were planted at each post, and each line consisted entirely of one species. the three species chosen were *Melia azederach, Tamarindus indica* and *Eucalyptus camaldulensis,* all of which have shown some promise. By planting lines right across the valley the seedlings will come under all the different conditions of soil and climate prevailing in the valley, and it is hoped that this will show whether planting trees in the more remote areas of the plains is possible. Depending on the results of this trial, the decision will be taken whether or not it is worthwhile continuing with tree-planting trials.

Plate II.—Persian lilac planted in the plains near Kafukola, Rukwa Valley, Tanganyika. There was a progressive decline in success on moving out from the natural tree line at the foot of the Fipa Escarpment (shown), until very few trees except native acacias survived at two miles distance.

SUMMARY

In the outbreak areas of the Red Locust (*Nomadacris septemfasciata* Serville) it was noted that large locust populations and the formation of swarms were confined solely to large areas of grassland, and that red locusts

were never found, except as scattered individuals, within the tree line. It was therefore decided to initiate tree planting trials in the grassland to investigate the possibility of their use, on a large scale, in the ecological control of the locust.

The Rukwa Valley in South-west Tanganyika is a part of the Rift Valley and is the main outbreak region of the red locust. The floor of the valley is covered by extensive grasslands and its climate and vegetation are described. It was found that the grassland area was generally unsuitable for tree growth and, from advice obtained from several forestry departments, trials were instituted to determine the most suitable tree species and the best planting methods.

Some success was obtained in the trials and the success and failure of the different species used are discussed.

Acknowledgments

I would like to thank Dr. D. L. Gunn, Director, International Red Locust Control Service, who initiated this project and who, throughout, has shown great interest and has always been ready with help and advice. I would also like to thank the Forest Departments of Southern Rhodesia, Northern Rhodesia, Tanganyika, Kenya, and Australia, for the interest they have shown in these trials. In particular, I would wish to thank Dr. A. L. Griffith, E.A.A.F.R.O.; Mr. M. Probyn, Conservator of Forests, North-west Circle, Tanganyika; Mr O. Kerfoot, Provincial Forest Officer, Northern Rhodesia; and Mr. R. Hopper, Forester, Tanganyika, who have visited the valley and have given us the benefit of their knowledge and experience.

THE NINTH INTERNATIONAL BOTANICAL CONGRESS

The Ninth International Botanical Congress will be held in Montreal, Canada, from 19th to 29th August, 1959, at McGill University and the University of Montreal. The programme will include papers and symposia related to all branches of pure and applied botany. A first circular giving information on programme, accommodation, excursions, and other details will be available early in 1958. This circular and subsequent circulars including application forms will be sent only to those who write to the Secretary-General asking to be placed on the Congress mailing list:

Dr. C. Frankton,
Secretary-General,
IX International Botanical Congress,
Science Service Building,
Ottawa, Ontario,
Canada.

CLIMATIC ZONES OF EAST AFRICA

By J. F. Griffiths, East African Veterinary Research Organization

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Climatic classifications are generally made with prime regard to temperature as the main factor. This was especially true for the early climatologists who used aspects such as a mean temperature of 20° C. as a dividing line. Later it was realized that this method was very limited since it dealt with only one factor, and rainfall was included as another variable on which to subdivide the climate. Since then many different methods of weighting the relative importance of the temperature and rainfall characteristics have been used, and a number of classifications have been constructed using other factors, such as evaporation, wind speed, and reliability of rainfall.

From the point of view of agriculture both evaporation, or evapo-transpiration, and reliability of rainfall are of great importance. The former allows a form of water balance table to be drawn up so that the moisture state of the soil can be deduced, thus indicating the need for irrigation at certain times. Sansom (1954) found that in East Africa, as in most of the tropical countries, annual and seasonal rainfall show variability slightly larger than that experienced in temperate countries. This fact is most important in East Africa, as the annual amount is quite often marginal for the crop concerned; for example the average annual rainfall may be 40 in. whilst the crop needs 35 in. In temperate zones it may be that 35 in. will be exceeded, so that the crop will thrive, in five out of six years (figures for Lerwick, Scotland), whilst in East Africa 35 in. is received in only two out of three years (figures for Embu, Kenya). The importance of having a measure of such variability is obvious and was first stressed and studied by Glover and Robinson (1953) whose work is of prime importance in this respect.

However, it is not sufficient to effect climatic classifications on single factors, and the purpose of this paper is to attempt to subdivide East Africa into zones in which there is fair uniformity of general climate so that differences between two areas may become immediately obvious. The work has been occasioned by the growing importance of bioclimatology in agriculture, animal husbandry and forestry. Bioclimatology seeks to study the effect of all aspects of the climate upon plant or animal life and to see how artificial modifications, such as wind-breaks, irrigation, radiation shelters, can be used to improve production as well as to assist in deciding whether certain crops or animals can thrive in chosen regions. For this it is essential to know the major climatic zones of a region so that interregional differences can be studied.

A noticeable feature of the climate of East Africa is the almost complete dependence of temperature upon altitude, so that any range of mean temperatures follows the topographical pattern. If a rough correction of adding 3° F. for each 1,000 ft. above sea level is adopted then all the corrected temperatures lie between 81° and 85° F., with the exceptions of the coast and lake shores which are cooled by local breezes, and the extreme north which is warmed by the advection of warm air from the Sudan and the Ogaden. This means that temperature cannot be used directly as a factor for climatic classification. Rainfall, as is to be expected, becomes the dominant feature of subdivision, in time of fall, variability, and amount. Precipitation in these regions may be due to the Inter-Tropical Convergence Zone (I.T.C.Z.) which moves from about latitude 15° S. to 15° N., following the sun with a time lag of about one month. Along this line, where it is well-defined, the winds from the two hemispheres converge, and on account of the ascending air currents the zone is generally marked by a belt of rain. During January the I.T.C.Z. lies over southern Tanganyika, later it moves northwards and reaches its limit in July about halfway across the Sudan before it travels southwards. On the coast, the south-east monsoon brings a moisture-laden air-mass across the Indian Ocean in April, May and early June, and the effect of the upper air winds associated with this often causes rain as far inland as the Uganda border. The winds from the Congo and Rhodesian regions can also give rise to quite heavy rainfall and investigations are being carried out on their influence.

In order to analyse the periods of rainfall a rainy month was defined as one in which the fall exceeded one-twelfth of the annual amount, and this leads to a reasonable limit being put upon the rainy season. The variability of rainfall was calculated in terms of a variability coefficient, defined as the difference between the maximum and minimum annual rainfall divided by the average. This method is inferior to calculating the standard deviation, but it is a quick method of obtaining a factor which can be correlated with the standard deviation.

For classification the diurnal range of temperature is more important than the mean temperature and also in this study use has been made of the difference between means of monthly temperature.

In order to avoid too many variables, the separate factors were correlated one with another and with altitude. Where a reasonable correlation existed between two factors one of them was ignored as being unnecessary to the classification.

CLIMATIC ZONES

Lake Rudolf (Zone No. 1 on map).

Rainfall is less than 15 in. over the whole region with a minimum of about 6 in. in the central lake area. The variation in the annual amount is quite large (coefficient 0.8) as is the time of fall. March, April and May are normally the rainy months, but there is a secondary maximum in the November-December period. Heavy rains can occur in July and August and, in all, the rainfall picture is a very unsettled one. Falls of 1.5 in. to 2 in. per day can be recorded and there are about 20 rainy days per year. March, with a mean of 87° F., is the hottest month, whilst August, mean 82° F., is the coolest. Although the mean annual range is small the diurnal range of 20° F. is high. As would be expected the relative humidity is low, averaging 45 per cent. The prevailing wind is east, varying to north-east/south-east. Cloud amounts to about 4/8 and there is seldom a completely clear sky.

Arua-Kitale-Kericho (Zone No. 2 on map)

This zone stretches from the north and north-west corner of Uganda down through north-west Kenya to the eastern edge of the Kavirondo Gulf and experiences rain during the single period April to September.

Except for the two regions, Karamoja and Kericho, mentioned later, the zone has a medium-high rainfall which, over the Uganda sector average over 50 in., with a range of about 40 in. to 75 in. In the Kenya sector the fall is somewhat less, 40 in. to 50 in., with a range of 20 in. to 60 in. January, with less than 1 in., is a dry month, while the rainy period usually has falls exceeding 5 in. per month. There are 100 to 150 rainy days per year.

The diurnal range increases southwards from 20° F. at Arua to 30° F. at Kericho. However, at the highest station, Equator (9,100 ft.), it is only 18° F. Temperatures range greatly over the area as altitude varies, but the northern region is some 1° to 2° F. higher than would be estimated on altitude considerations. Mean relative humidity is about 65 per cent.

Around Kericho there is a region of high rainfall, 60 in. to 70 in., with a range of 50 in. to 95 in. Most months from March to October have over 5 in. rain, but, as in the main part of the region January is dry. Here there are 200 rainy days per year. To the west of the region, around Kisii, it seems that a north to south-west air flow causes orographic precipitation and rain (over 2 in.) results in each month. The diurnal variation of 30° F. is large, whilst the relative humidity, 50 per cent is surprisingly low for such a moist region.

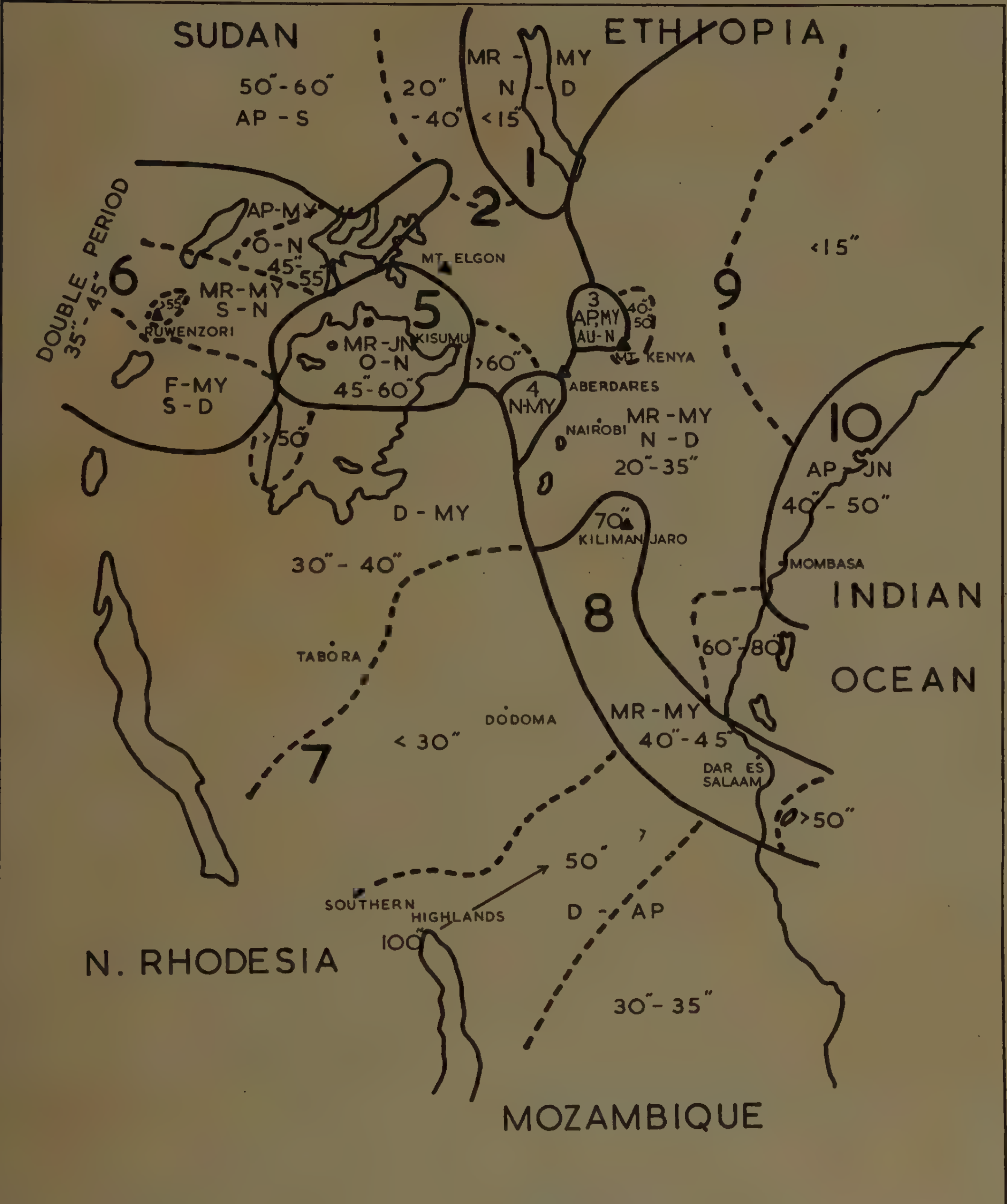
The Karamoja region in the north-east of the zone is one of much lower rainfall, 20 in. to 40 in., gradually blending in with the very dry scrub land of the Turkana. The rainfall shows a slight June maximum.

Nanyuki (Zone 3)

This small zone lies to the west of Mount Kenya and covers about 400 square miles. There are two periods of rain, April to May and August to November. Over one-sixth of the annual rainfall of 25 in. to 30 in. comes in April, but amounts exceeding 5 in. are unusual. The range is about 20 in. to 40 in. and there are about 110 rainy days per year. This is in excess of the number that would normally be expected from such a rainfall. The diurnal range is about 25° F. to 30° F. and relative humidity is about 60 per cent. There is a tendency for winds to back from south to east during the day.

Narok (*Zone* 4)

A zone, of about 2,000 square miles around Narok and extending down towards Lake Eyasi. Rain falls mainly during the period November to May with an annual average of 25 in. to 30 in. The variation is



CLIMATIC ZONES OF EAST AFRICA

very large and annual amounts of from 10 in. to 50 in. can occur. During June to October, falls mostly total about 1 in. About 100 rainy days are recorded each year. The average relative humidity is 60 per cent. Winds are predominantly south-east/south.

Northern Lake Victoria (Zone 5)

Rainfall occurs in two periods, March to June and October to November, and there is no really dry month. The annual fall is between 45 in. and 60 in., except to the south-east of Entebbe, the variation coefficient being about 0.4 in the Kenya region and 0.8 at Entebbe. The diurnal range increases in the opposite direction being 15° at Entebbe and 25° at Masara. Rain falls on about 125 to 155 days of the year.

Owing to the proximity of Lake Victoria there is little variation in mean monthly temperature, only about 4° F. The land and lake breezes mainly control the wind direction. The relative humidity decreases from Entebbe (77 per cent) to Kisumu (62 per cent). Cloud cover is higher on the west (6/8 to 7/8) than on the east.

Western Uganda (Zone 6)

This zone comprises most of Uganda, save for the West Nile district, the north and the lake-side belt. It is characterized by the presence of two distinct rainy seasons. Proceeding northwards there is a convergence of the two seasons during the mid-months.

Southern Region.—The two rainy seasons are February to May and September to December, with an annual total of 35 in. to 40 in. June and July are dry months but no month has over 5 in. The variation coefficient is 0.6, a range of about 30 in. to 60 in. The number of rainy days decreases from west to east, 160 to 20. Diurnal range is about 22° whilst the variation of mean monthly temperature is extremely small, only 2°. This is a cloudy region with high humidity (70–75 per cent) and little evaporation (1.5 mm. per day or 22 in. per year).

Central Region.—The rainy seasons are March to May and September to November, with an annual total of 35 in. to 45 in. The variation is about 0.5, or 30 in. to 55 in. Around Ruwenzori there is an area of high rainfall and cloud amounts, the annual fall being about 55 in. to 80 in. There are more rainy days than in the southern zone, 140 to 180 days, but there is less cloud, except around Ruwenzori. Diurnal and mean monthly temperature variations are very like those in the southern region. Relative humidity is about 75 per cent.

Northern Region.—The rainy seasons are April to May and June to November. In the western sector the rainfall increases towards the higher land in the east, from 30 in. to 35 in. The variation coefficient is very small, 0.4, 25 in. to 40 in. as is the diurnal variation, 15° F. The main monthly temperature variation is 4° F. and the average relative humidity 72 per cent. There are considerable cloud amounts.

In the eastern sector the rainfall is higher, over 50 in. decreasing to 35 in. in the north-east, whilst the rainy days follow the same pattern, varying from 140 to about 70. The variation coefficient is about 0.6. Unlike the western sector, there is little rain during November. January is a relatively dry month.

Western Tanganyika (Zone 7)

This climatic zone includes most of Tanganyika, stretching from the Uganda border in a south-easterly direction to the coast. The only part of the territory not included is the north-eastern corner adjoining Kenya. The whole zone has a single rainfall period and is subdivided as in Zone 6 on the amount received and a slight variation in the main time of precipitation.

In the Bukoba region the rain falls during December to May and is quite high, 50 in. to 80 in. The variation is about 0.5; there are more than 150 rainy days per year and there is no really dry month of less that 1.5 in. The mean monthly temperature variation is very small, 2° F., and the diurnal range is 20° F. There is very little evaporation and the relative humidity is 78 per cent.

In the northern region, as with Bukoba, rain falls during December to May but totals much less, 30 in. to 40 in. There is actually some November rain in the west. Variation is greatest in the central region, Tabora having limits of 15 in. to 51 in. This decreases outwards, Kigoma having a variation coefficient of only 0.6 (25 in. to 45 in.). There are between 100 and 120 rainy days per year. On the average four months of the year have less than 1 in. of rain, there being almost absolute drought to the south and south-west (excluding the region around Lake Nyasa) in June to August. The mean annual temperature is about 74° F. with a small monthly range, except in the Central Region where there is a range of some 8° F. The diurnal range follows the same pattern. The west and south sectors experience high evaporation. In the central sector prevailing winds are easterly but on the lake edges land and water breezes persist.

In the Central Region the average annual rainfall is from 20 in. to 30 in. with December to April as the rainy months. There are five or six months of near drought from June to October and the number of rainy days is only about 60, although this tends to increase towards the hills in the south-east, whilst the rainfall variation decreases outwards from Dodoma (1.4) to about 0.8 on the border of the region. The diurnal variation is over 20° F. and the mean monthly temperature range is between 7° F. and 9° F. The evaporation is high with a low relative humidity of 65 per cent. Winds again have a predominance from the east.

The Southern Highlands Region also has its main rainy period from December to April as in the Central Region, but the total fall averages from 35 in. to 115 in. The maximum fall is near to Lake Nyasa, with amounts decreasing towards the north-east except on high land. The variation is about 0.8 and there is a mid-year drought. There is a great variation in the number of rainy days from 100 in the north to 170 in the south. Diurnal variation is about 20° F. and the mean monthly variations of 10° is quite high for the territories.

In the Southern Region rainfall occurs in the period December to April as in the Central and Southern Highland regions, with an average of 30 in. to 35 in. and a variation of 0.7, from 25 in. to 50 in. There are about 100 rainy days over the whole region. The diurnal temperature variation is from 16° F. to 18° F. with a mean monthly temperature range of 5° F. to 7° F. The evaporation is small, being only about 2.5 mm. per day, 35 in. per year.

Kilimanjaro-Masai Steppe-Dar es Salaam (Zone 8)

Rain falls during the period March to May with August and/or September as the driest time. The falls usually exceed 10 in. in April and May, but average only about 40 in. to 45 in. per year, save on the slopes of Kilimanjaro (70 in.). The rainfall variation is about 0.8 and the number of rainy days varies greatly—130 at the coast, 70 to 90 inland, and 160 or more at Lyamungu, on the slopes of Kilimanjaro. The diurnal temperature range increases away from the coast from 12° F. to 18° F.

On the island of Mafia rain falls at the same season as in the rest of the zone with perhaps a little less in March. Totals range from 45 in. to 85 in. with amounts tending to increase towards the mainland. This unusual pattern must be studied in more detail before any explanation can be advanced.

Central and Northern Frontier Provinces of Kenya (Zone 9)

This zone stretches from the borders of Ethiopia and Somalia southwards through Kenya then swinging south-eastwards to meet the coast along a small stretch just south of Mombasa. The whole zone has a double period of rainfall from March to May and November to December, the regions being identified mainly on amount falling with some slight time shift.

In the Coastal Region rains are mainly from March to May with a slight November-December maximum. They are associated with the I.T.C.Z. as the region seems to be just beyond the area influenced by the south-east monsoon. The annual rainfall averages over 70 in. near to the coast, falling off gradually to merge with the smaller rainfall of Central Kenya. There are some 150 to 200 rainy days the number decreasing away from Amani District, the opposite of the variation coefficient, Amani with 0.45 being one of the lowest in the territories while variation at the coast is about 0.7. Diurnal variation and mean monthly temperature range increase away from the coast.

The Garissa-Mandera Region, although having rains in the period March to May and at the end of the year is greatly influenced by the relatively dry, warm air sweeping down from the Ogaden and amounts are correspondingly lower, being less than 15 in. in general and below 5 in. around Wajir. In the north, June to August are almost completely dry, but near Garissa some rain is recorded in all months.

Temperatures are a little above the average sea level temperatures and reach mean annual temperatures in the upper eighties. Diurnal variation is about 20° F. Relative humidity is low at about 60 per cent, and evaporation is high, being nearly 100 in. per year at Mandera. Winds are mainly from the east-south quarter.

The Slopes of Mount Kenya is a region very like that of Central Kenya, but owing to the proximity of the mountain and the corresponding ascending currents, falls are greater. The annual average is between 40 in. and 55 in., with the rainy season beginning in mid-October.

The Central Kenya Region experiences the marked double period of the long and short rains. The average annual fall is between 20 in. and 35 in. with July as the driest month less than 1 in. Rainy days number from 70 to 100, but in the Naivasha-Nakuru belt this can increase to 130, a very high figure for so low a rainfall. The variation of rainfall can be very considerable and a maximum point for this factor exists around Makindu (2.6; range 3 in to 69 in.) falling off in both directions to about 1.2 around Nairobi, 1.8 at Voi and 0.8 in the north.

Temperatures vary from 56° to 73° but are nearly constant at 83° when reduced to sea level and diurnal variation is about 20° F. Except in the extreme north mean monthly temperatures vary by about 8° F. Relative humidity is about 60 per cent, and evaporation around 2.5 mm. per day, 35 in. per year. Winds are predominantly from the eastern sector.

Kenya Coast (Zone 10)

Rain begins in April with the advent of the monsoon and ends in June in the north and in July at Mombasa. Here the annual fall is about 47 in. but this decreases to the north, Lamu having 37 in. Owing to the unstable nature of the monsoon the rainfall variation is high. Lamu, for example, sometimes getting little or no monsoonal rain, has a variation coefficient of 1.6, but this decreases southwards, Mombasa being 1.1. January and February are dry months, whilst over 10 in. is usually recorded in May. Rainy days increase southwards from about 90 to 140. The diurnal temperature range is small, 11° F. to 14° F. The wind direction is mainly dependent upon the land and sea breezes but the land (westerly) breeze seldom seems to prevail in the north. Relative humidity is high, 75 per cent to 80 per cent.

Some Climatic Extremes from Main Recording Stations

Temperature

Highest on record—Mandera (104°) and Garissa (103°) are the only places to record over 100° in Kenya. In Uganda, Kitgum (101.6°), Serere (101.1°) and Lira (100°) hold the record, whilst in Tanganyika, Moshi (99.9°) and in Zanzibar, Chukwani (101.9°); record the extremes. Lowest on record —Kenya—Narok (32.9°); Tanganyika, Mbeya (35.7°); Uganda—Fort Portal (43.9°); Zanzibar Town 63°.

Chukwani has never recorded less than 67° whilst Equator has never been above 75°.

Days per year with maximum above 90°—Garissa (316), Magadi (312), Mandera (288), Wajir (22), Kitkum (150), Moshi (102).

Rainfall

Most in one month: Kenya—Malindi (48.7 in); Uganda—Entebbe (24.8 in.); Tanganyika—Kyela (60.7 in.); Zanzibar, Chukwani (34.5 in.).

Extremes in one year: Mandera (1.7 in.) and Kyela (156 in.). The highest for each territory is 89 in. at Entebbe (Uganda), 97 in. at Kericho (Kenya), and the above figure for Kyela (Tanganyika). Kyela recorded 10.4 in on 16th April, 1946.

Voi, Makindu and Wajir have all had zero rain in each month. Kericho experiences the most rainy days per year, 207, with Mandera the least, 22. Kericho averages 26 rainy days in May, and Dodoma averages only three days in the period May to October.

Cloud

In the morning Kericho has the least cloud (2/8) and Bukoba the most (7/8), in the afternoon Lamu (3/8) and Mbale (7/8) are the extremes; for daily totals Lamu is the minimum (3/8) and Jinja the maximum (6/8).

Relative Humidity

Highest annual average: Amani (Tanganyika), 80 per cent; Lamu (Kenya), 79 per cent; Entebbe (Uganda), 77 per cent; Chukwani (Zanzibar), 78 per cent.

At 08.30 Kericho has seven months with relative humidity over 94 per cent. At 14.30 Lamu has 11 months with relative humidity over 75 per cent. The lowest readings ever noted are 7 per cent at Kisumu and 8 per cent at Naivasha which has a diurnal range of 62 per cent.

Evaporation

Magadi has the highest annual evaporation 111 in. per year, and Amani the lowest with 13 in. per year.

The maximum evaporation in 24 hours has been 0.57 in. at Magadi and 0.56 in. at Kitgum.

Sunshine

The maximum annual daily total is 8.5 hours at Tabora and Mombasa.

The maximum daily record is 12.3 hours at Chukwani, but this is approached by the 12.2 hours at Tabora.

Wind

In Kenya, Isiolo is the windiest spot with about 22 per cent of the records over 24 m.p.h.; Uganda's record is held by Mubende with 20 per cent; in Tanganyika Sao Hill has 6 per cent over 24 m.p.h. at 08.30 and Amani 11 per cent at 14.30.

Kabete, Voi, Lindi, Mpwapwa and Songea have never recorded winds over 24 m.p.h., Songea only having winds above 13 m.p.h on 1 per cent of the records.

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Vol. 4, Nos. 1 and 6.
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THE EFFECT OF INSECTICIDAL SPRAYING AGAINST GLOSSINA PALPALIS FUSCIPES, NEWSTEAD IN THE NYANDO RIVER BASIN OF KENYA

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This paper deals only with the tsetse fly, *Glossina palpalis fuscipes,* Newstead which occurs in Kenya along the shores and on the islands of Lake Victoria and along many of the rivers running into it. There were no other species of tsetse in the area with which we are concerned. *G. palpalis* was found up to an altitude of 5,250 feet in the Nyando river basin vegetation fringing the rivers and sometimes forming patches of forest.

The Nyando River rises in the Nandi escarpment and flows in a westerly direction into Nyakach Bay, in Lake Victoria, 14 miles south-east of Kisumu. Two main tributaries—the Mbogo and the Ainomotua—join the Nyando river near Kibigori. These three rivers have numerous perennial tributaries, flowing mainly from the escarpment in the north or from the hill country in the south. The basin in which the rivers flow covers an area of approximately 300 square miles. It is isolated by high hills on three sides and by cultivation on the fourth.

Human trypanosomiasis was reported in the Nyando River basin as early as 1915, while *Trypanosoma vivax* and *T. congolense* had been known to occur in cattle in this area as far back as 1927 (Lewis, 1947).

Following an outbreak of sleeping sickness in 1948-49 when 58 cases were diagnosed at or near Kibigori (Heisch, 1949) it was decided to clear by hand-labour the vegetation on some of the banks of tsetse-infested streams flowing into the Nyando River, but the ultimate total cost of this method would have been prohibitive and it soon became evident that regeneration was a serious problem, so hand-clearing was discontinued in favour of a trial with insecticides. A ten-mile stretch of river below the junction of the Mbogo and Nyando rivers cleared at that time has remained open due to intensive cultivation by the local Africans and has acted as a very effective barrier to reinfestation of the rest of the river system.

It was decided, therefore, on the advice of the Officer-in-Charge of the Colonial Pesticide Research Unit to test the efficacy of insecticides against *G. palpalis* in this kind of country by using the knapsack "Four Oakes" pump to spray vegetation from the river bed wherever possible, or along specially cut paths on the river banks near the water's edge.

CONTROL OF G. PALPALIS BY DDT SPRAYS

In Uganda, spraying experiments done by the Colonial Pesticide Research Unit with DDT and Benzene Hexachloride on islands in Lake Victoria had shown that the density of this fly was considerably reduced, but only temporarily, (Symes, Hadaway, Barlow and Galley, 1947; Woodcock, 1949); complete elimination was never achieved in these experiments.

1951–1952

The first work with insecticide sprays in the Nyando River basin has been described by S. G. Wilson (1953). Under the direction of Mr. K. S. Hocking, Officer-in-Charge of the Colonial Pesticide Research Unit, in close collaboration with Dr. S. G. Wilson of the Kenya Tsetse Survey and Control Section who were responsible for the fly catches, the first 20 miles on the Mbogo River were sprayed by Mr. Woodcock and from then onwards the work was taken over entirely by Dr. Wilson, and a further 37 miles of the Ainomotua River and its tributaries were sprayed with five per cent DDT mixture, obtained originally as either a paste or an emulsion, i.e. 57 miles of river were sprayed in the first phase of the operation.

1954–1955

From 1952 to 1954 work in the Nyando River basin continued only on a small scale, surveying and re-spraying areas where odd flies occurred, but in 1954 an attempt was made to exterminate the fly from the entire river basin on the lines described by Wilson, giving four applications of insecticide at intervals of 14 days, as tests made by the Colonial Pesticide Research Unit had shown that the insecticide at the dilution used had a "residual effect" lasting at least 21 days. Thus it was thought that an interval of 14 days, when the toxicity was still very high, would give a fair margin of safety and also fit in with pupal emergences, so that the insecticide would always be strong enough to kill young (teneral) flies appearing some time after its application.

Arkôtine S.D. 18 (supplied by Messrs. Shell Chemicals) was used exclusively from 1954 onwards. It contained 15 per cent W/V technical DDT and was diluted with a proportion of 1:2 water to give a final strength of five per cent DDT W/V emulsion. Due to periodic rainfall and resulting administrative difficulties the rule of four applications at 14-day intervals could not always be rigidly adhered to, so the sprayings continued until the middle of 1955. After that only the sections in which flies recurred were resprayed.

From March, 1954, until December, 1955, regular patrols along the Nyando River and its tributaries (excluding the Mbogo and Ainomotua) revealed that a monthly catch of between 1,600–2,000 *G palpalis* before spraying began had been reduced to a maximum monthly catch of five flies in the whole sprayed area after the main campaign had been completed. In October, 1955, a non-teneral (old) female caught along the Nyando River was found to be un-fertilized. This appeared to indicate that the population had been so reduced that the sexes were failing to find each other.

Nevertheless, intensive surveys in mid-1955 disclosed that the main Nyando River and some of its tributaries still harboured *G. palpalis* in the upper unsprayed reaches where no fly had been found in 1949. It was also discovered that *G. palpalis* still existed on some parts of the Mbogo and Ainomotua rivers and their tributaries, though in far fewer numbers than before the 1951 spraying. This was annoying, but understandable, for several smaller tributaries of these two rivers were not sprayed in the 1951–52 operations as no fly had been found there at the time, and also G. *palpalis* could have dispersed there from the southern section where spraying did not begin until 1954.

Final Operations, 1955–56. Spraying and "mopping-up"

The upper infested regions of the Nyando River and its tributaries were sprayed five times, adhering to the rule of fortnightly applications as closely as possible, during the second half of 1955. In January and February, 1956, the infested areas of the Mbogo and Ainomotua rivers and their tributaries were similarly treated, but it was gratifying to find that the upper Ainomotua had not been reinfested and had remained free from fly since the 1951–52 sprayings.

Whenever the presence of fly was established on a fly round covering the sprayed area, that section was again sprayed below and above the point of capture, over a distance of at least half a mile. If forest or reeds extended any distance from the river at the point of capture, transverse paths were cut through the bush at 40-yard intervals and these were also sprayed.

From January to March, 1956, only four flies were found in the northern (Mbogo and Ainomotua) sections and none after that month. In August one more uninseminated female fly was found on the main stream of the Nyando River—the only fly caught in the southern section throughout the year.

From April to June, and again from October to December, 1956, the Nyando River basin system was intensively surveyed by two European Officers in addition to the regular monthly fly rounds, without finding a single tsetse fly in the many miles of river searched. Such results lead us to believe that extermination may have been achieved, for up to the present (June, 1957) no flies have been caught in the whole area. A continual check will be kept, and should flies reappear anywhere, the region concerned will be sprayed immediately. The nearest known tsetse area is 30 miles away on the River Miriu, a few miles south of Nyakach Bay.

COSTS

In 1951 the cost of four sprayings of riverine bush was estimated by Wilson (1953) to be £42 per river mile. This included the cost of insecticides, transport, cutting of paths and labour. In 1954, due to the increase in prices and rising wages, the cost had risen to £57 per mile and by 1956 this had increased again to £68 per mile. The purchase price of a gallon of Arkotine S.D. 18 varied between Sh. 19/50 and Sh. 15/75 and using the higher figure the cost of the insecticide for four sprayings came to approximately £40 per mile during the years 1954–1956. Wages rose sharply during these years so that to the cost of £40 per mile must be added £17 in 1954 rising to £28 in 1956. This represents the cost of transport, cutting of paths, European supervision and African wages. Even at £68 per mile, and including the re-spraying of the northern sector, the overall cost of spraying the Nyando River was still considerably cheaper than hand-clearing which worked out at £200–£300 per river mile in 1952, and since then the costs have increased in addition to the vexed problem of the control of regrowth. From 1954 when the second phase began, to 1956 when the last fly was caught, the total cost of this part of the scheme has worked out at between £5,000 and £6,000 and the length of river treated was approximately 80 miles. Thus the total length of river sprayed in the whole operation from 1951 to 1956 was 137 miles.

DISCUSSION

Since the outbreak of sleeping sickness in the Nyando basin area in 1948–49 only a few sporadic cases of the disease have occurred, and it is believed that all recently diagnosed cases are of long duration (Nelson, 1956).

No cases of animal trypanosomiasis have been reported for the last few years. In 1956 thick smears were taken from 550 head of cattle at the Veterinary Farm at Kibigori and all proved negative. Thus it would appear that by the eradication of *G. palpalis* bovine trypanosomiasis had died out in this area by 1956, indicating that tsetse was the responsible agent for the maintenance and spread of the disease and that other biting-flies were apparently of little importance.

Various lessons were learnt in these operations which should benefit future schemes in that it is felt that an all-out attack at the beginning with four properly organised teams could have finished the work in six months and obviated the possibility of the reinfestation which occurred along certain rivers. Some gorges were impossible to spray effectively on account of their inaccessibility and it was found that by spraying heavily and repeatedly at both ends of these it was possible to destroy the fly as it emerged in search of food. It was found also that wherever possible spraying programmes should be executed in the dry or drier seasons, for during heavy rain the insecticide is washed from the leaf surfaces, while spraying from the river beds may become impossible on account of flooding.

SUMMARY

A severe outbreak of sleeping sickness in 1948–49 led to measures being taken to eradicate the fly *G. palpalis* from the Nyando River basin. Hand-clearing proved uneconomical, so a pilot scheme in the use of insecticides was launched in 1951 along the northern rivers, where fringing vegetation was sprayed at 14-day intervals on four separate occasions with a five per cent solution of DDT made from a paste or emulsion.

Despite spectacular decreases in *G. palpalis* after this initial operation further work was held up, mainly because of the Emergency, until 1954 when spraying was resumed on the main river and its tributaries to the south using similar methods but applying a five per cent DDT emulsion known as Arkotine S.D. 18.

The main work was completed by mid-1955 but it was found that *G. palpalis* now extended beyond its former limits although previous surveys had not located it there, and had also reappeared in parts of the northern system of rivers, which had been sprayed before. These infested areas were sprayed and the work finally completed in April, 1956.

Only five *G. palpalis* were caught in 1956, the last in August of that year. Up to the end of June, 1957, no further catches have been made.

Costs of spraying increased from £42 per river mile in 1951 to £68 by 1955, but still compare favourably with hand-clearing which is now more than £300 per river mile.

ACKNOWLEDGMENTS

Acknowledgments are due to the Director of Veterinary Services, who has given us permission to publish this paper, to the Colonial Pesticide Research Unit who gave technical, financial and practical assistance in

the early stages of the spraying operation and who kept an interest in the work throughout. Also to Dr. S. G. Wilson, C.B.E., who initiated the work and to the present head of our Section, Dr. P. E. Glover, M.B.E., who completed it. Further, our thanks are due to Mr. J. G. le Roux who did a large amount of work on this scheme, to Mr. E. C. Trump who made the map and to various other officers of the Tsetse Section who have participated in the work, and some of the local farmers. Finally, we would like to record the excellent and conscientious work of our African supervisor Akula, who has been in charge of the fly-boys and spraying teams since the scheme began.

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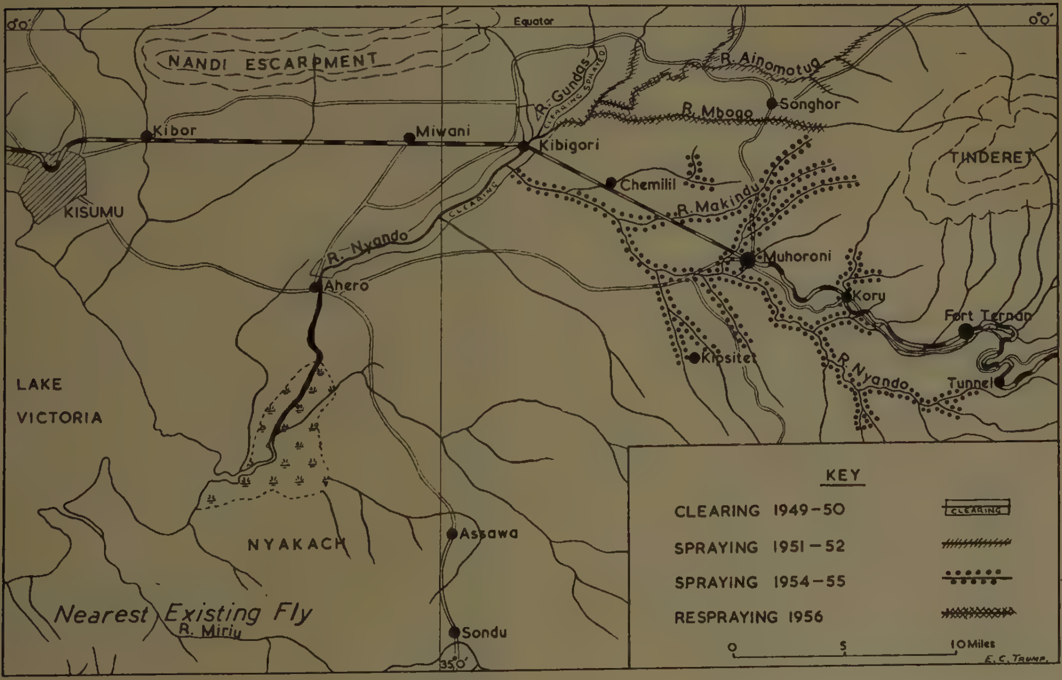

GULLY UTILIZATION AND EROSION CONTROL

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It has been customary in many parts of Africa to place much emphasis on gully protection; and it is commonly believed that natural climax vegetation affords the best form of protection that can be provided. As the result of investigational work carried out at the Mpwapwa Veterinary Research Station, however, a better solution has been found for deciduous thicket vegetation.

Active gully erosion continues to take place under cover of dense indigenous deciduous thicket that has been given complete protection for many years, particularly along foothill areas on steep fan slopes. Although the roots of this vegetation type must inevitably afford considerable protection, erosion continues at a very marked rate. The deciduous thicket does not provide satisfactory arrest against the ravages of heavy downpours, especially during the early part of the rainy season when there is no foliage to break the force of the rain.

It has generally been considered unwise and uneconomic to clear the gullies, and this doctrine has been widely expounded without challenge or much further thought; this is in spite of the fact that these bush-covered gullies, adjacent to cultivated slopes with standing crops, provide excellent harbouring places and ideal cover for birds, buck, and vermin such as wild pig and baboon. At the same time they continue to erode and contribute nothing towards the farm income. Furthermore, the thicket vegetation along the gullies denies access to grazing animals, which are forced to trample new paths up and down the slopes and thus continually add more gullies and cause further devastation. Deciduous thicket, due to competition for light and moisture prevents grass growth; and, therefore, grasses cannot spread from adjacent fields into thicket-clad gullies, which remain indefinitely completely void of ground cover.

On clearing some of the gullies and planting Star grass (*Cynodon plectostachyum*) and elephant grass (*Pennisetum purpureum*) it was found that the grasses become readily established. Star grass spreads sidewards as it holds back soil particles and additional moisture, thus expeditiously covering and stabilizing the bare gully banks and edges, while numerous other indigenous species soon infiltrate and help to provide additional ground cover. As the result of such grass growth, a fertile gully floor, where moisture is readily available, is soon created. This is found to be capable of producing more than three times the amount of fodder than can be obtained from well-tended improved pastures on the adjacent slopes. Up to 68 tons per acre of green elephant-grass fodder have been cut during low rainfall years from gullies that were previously very badly eroded. It would also seem that this production could be improved upon considerably in many parts, if fairly wide and more suitable drainage lines are selected for establishing this fodder grass. On the whole, star grass seems to be more suitable in areas with very low rainfall and for narrow, steep gullies.

Plate I.—Mpwapwa District. Serious gully erosion at Chunio in an area where there is not sufficient perennial grass to stabilize the soil.

On 9th March, 1954, 11 iron standards were placed in gullies planted to star grass and elephant grass. In each case 60 in. remained above ground level at the time. They now indicate a considerable amount of silting and one is only 36 in. above present ground level. The respective heights in inches of the standards above ground level on 20th July, 1956, were:—

(*a*) *In the gully planted to star grass*: 52½, 48½, 45, 50½ and 36 in. This represents an average sand and silt deposit of 13½ in. over a distance of about 200 yards.

(*b*) *In the gully planted to elephant grass*: 54, 52, 44, 55, 50½ and 48½ in., representing an average sand and silt deposit of 11 in. over a distance about 350 yards.

Plate II.—Kondoa Irangi. A demonstration of the recuperative powers of badly eroded soil. Note the extent to which the soil has been stabilized as the result of grass growth due to protection for two years.

When gullies are stabilized in this way by grass growth, they not only provide good supplies of fodder or grazing but they can be used as access tracks for livestock, thus preventing further devastation of adjacent fields, which would otherwise be ruined by additional cattle tracks resulting in further gullying. Once star grass is firmly established along existing gullies, it can stand a tremendous amount of wear and tear since it is not easily trampled out or pulled up by the root, as is frequently stated. In any case, should a certain amount of erosion still continue along the gully edges, it would take place in an already eroded gully and not on adjacent agricultural land that is still intact and can be saved from destruction.

Plate III.—Mpwapwa District. Barriers erroneously constructed and trees felled across a major drainage line at Chunio with the object to check the flow of water. A good example of what NOT to do.

"Gully stopping" is often attempted by erecting barriers or by placing brushwood in watercourses. This, however, is a very dangerous practice, as almost invariably the brush is washed downstream during heavy storms and sometimes the water is diverted from its normal course in places where "bottlenecks" cause blockages, with the result that it overflows on adjacent cultivated fields causing damage. The brush is also likely to choke road and rail bridges or culverts, causing washaways and damage to structures. Where large barriers are constructed across the drainage lines, they either get swept away or, if they offer too much resistance, the banks on the sides are washed out and the spread of erosion is increased. Cut brushwood can, however, be used very beneficially for covering bare ground and gully banks, as well as side offshoots that do not carry much water. If used in this way, the brush cover also encourages grass growth to a considerable extent, as it holds up seeds and some moisture while also protecting the seedlings against the elements and stock.

Low stone packing on gully floors are also very useful to arrest sand and silt, thereby encouraging grass growth. These must, however, be low and wide so that water can escape over the top without the stones being swept away. After siltation, the height of the stone packings can be increased repeatedly as long as the process of sand and silt deposition continues.

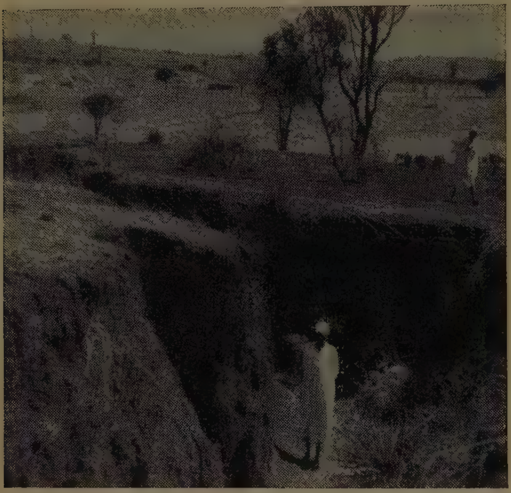

Plate IV.—Mpwapwa. Gully erosion where a break occurred in a contour bank. This could have been obviated if provision had been made for the surplus water to be discharged into an existing gully indicated by the figure of the person standing behind.

In order to protect the slopes against erosion from run-off water surplus to the absorptive capacity of the soil, especially during heavy downpours, graded or "sloping" contour banks capable of discharging the run-off water gradually into adjacent gullies are constructed at Mpwapwa at suitable intervals across the slope. When the water is discharged into grassed gullies which in turn discharge it into larger drainage lines, similarly protected, no further excessive damage is likely to take place. The fields would then remain intact and their productivity could be increased. The capacity for moisture absorption of the soil can be improved considerably by thorough cultivation by ridging, tie-ridging and by inter-row cultivation.

The top few banks, particularly at the bases of steep hills or rocky slopes, should be made large enough to act as diversion banks to dispose of all the water from the hillsides, thus preventing it from washing across the fields and unnecessarily causing excessive damage. During heavy downpours, however, total absorption cannot be achieved over extensive areas and unless adequate provision is made for disposal of the water that has not been absorbed, disaster may follow. Most soil types are unable to absorb the rain-water at the rate of fall during heavy storms and, unless adequate steps are taken to guide this water off the slopes into adjacent drainage lines, the fields suffer severely in places where accumulated volumes of water eventually burst through the banks, for example in hollows and on land where the surface is irregular. The damage is sometimes accentuated by local accumulations of water discharging from adjacent hard patches of soil, from buildings or from roads, where there is inadequate provision for flood water to be discharged in a suitable way.

Care should be taken that water diverted from fields actually enters the drainage lines and that it is not blocked and compelled to flow back into the field; thus causing secondary gullies alongside existing ones. This situation is often aggravated in places where footpaths or tracks are formed at the edges of fields parallel to existing gullies.

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A METHOD OF ESTIMATING LIVE-WEIGHTS IN SMALL SHORTHORN ZEBU CATTLE FROM LINEAR BODY MEASUREMENTS

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In Africa where weighbridges are seldom available except in the large towns and on Government farms, an accurate method of live-weight estimation is invaluable, especially where drugs are being used, the dosages of which are based on knowledge of the patient's weight. Many different measurements have been used to estimate the live-weight of cattle. Significant relationships have been found between weight and heart girth measurements in European dairy breeds (Ragsdale, 1954; Branton and Salisbury, 1946) and in beef and dual-purpose breeds (Johnson, 1940; Wanderstock and Salisbury, 1946). Johansson and Hildeman (1954) found similar relationship with slaughter weight in European cattle. Wanderstock and Salisbury (1946) concluded that the most significant single measure for estimating weight in beef cattle was the heart girth measurement which was only slightly less significant than the more detailed estimation using the Minnesota Formula. (Johnson, 1940).

Reports of similar relationship between linear measurements and body weight in African breeds of cattle are more limited. Bonsma and Neser (1951) record significant relationships in Afrikaner and Afrikaner cross European cattle. The Uganda Veterinary Department Annual Report of 1944 records a satisfactory method of estimating live-weights of Small Shorthorn Zebu bullocks using an abdominal girth measurement taken 2″ anterior to the prepuce. Manning and Williams (1950) cite a method for estimating the live-weight of Small Shorthorn Zebu bullocks. This method depends on the calculation of a linear regression using an index of capacity derived from the product of the square of the heart girth and the body length, measured from the hump to the pin bone. This method gave fiducial limits of 95 lb. at the 0.05 figure of probability.

For field purposes of weight estimation the above reports concerning the Small Shorthorn Zebu cattle are of limited use in that they have only considered bullocks; whereas what is required is a method applicable to cattle of all ages and both sexes. Ross (1955) compared the relative efficiency of four methods of estimating the weight of varying ages and of both sexes. One method based on modification of the "Minnesota Formula" (Johnson, 1940), ($W = G^2 \times L \div 300$, where G = heart girth in in. L = body length in in. and W = weight in lb.) was considered to be a reasonably simple method and is further investigated here.

It was necessary to alter Johnson's Formula, which was calculated from measurements of European cattle, to suit the Small Shorthorn Zebu. Due to the presence of the Zebu hump and to its considerable variation in size and position the length measurement from withers to tail root was considered impractical. An alternative measurement of length from the point of the shoulder to the tuber coxae was used. The constant of 300 used by Johnson was altered to 213. This constant was selected by correlating measurements with actual weight.

MATERIALS AND METHOD

One hundred and eight cattle of both sexes, and ranging in age from one week to seven years, from two African local Government and one Protectorate Government Farm in Teso District, Uganda, were measured. Weight recordings in lb. were made between 7 and 8 a.m. before the cattle had access to grazing or water. The heart girth measurement was recorded using a ½″ cloth tape graduated in inches. The measurement was taken just behind the forelegs at the smallest circumference, the tape being pulled tight enough to keep the hair down but not to indent the flesh. Body length was recorded with the same cloth tape with the animal in a normal standing position. This measurement was taken three times, twice on the animal's right side and once on the left side and the average of the three readings recorded. Measurements were recorded in inches.

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RESULTS

For convenience in analysis the cattle were divided into four groups based on weight ranges of 200 lb. The difference of the estimated weight from the actual weight was calculated as a percentage of the actual weight. The number of animals whose weights were estimated to within two, five and ten per cent in the various weight groups, are shown in Table I, along with the mean deviations and standard errors.

TABLE I—FREQUENCY OF PERCENTAGE DIFFERENCES IN ACTUAL/ESTIMATED WEIGHTS IN FOUR WEIGHT GROUPS

WEIGHT GROUP	Under 2%	Under 5%	Under 10%	Over 10%	Mean Dev.	S.E.of Diff.
1–200 lb.	14	28	38	10	+1·3	1·29
200–400 lb.	4	7	12	3	+0·2	6·5
400–600 lb.	7	16	23	4	+7	6·03
600–800 lb.	1	8	14	4	−2·5	15

An analysis of the results show that there is little variation in the accuracy of the formula with the different weight groups and that the estimated weight came within two per cent of the actual weight in 23 per cent of the cattle, to within five per cent in 54 per cent of the cattle, and to within ten per cent in 80 per cent of the cattle. No difference was evident in the accuracy of the formula between sexes. The modification of Johnson's Formula described would thus appear to be a reasonably accurate method of weight estimation applicable to the Small Shorthorn Zebu. Being fairly simple it would be suitable for field conditions. Further investigations might suggest an alteration of the constant of 213 to obtain a greater degree of accuracy in varying age and sex groups, but the present data does not indicate that this would be necessary.

SUMMARY

A modification of the Johnson's Formula, $W=G^2 \times L \div 213$ (where W=weight in lb., G=heart girth in in., and L=body length in in.), is investigated and recommended as a suitable method for estimating the body weight of Uganda Small Shorthorn Zebu cattle from linear measurements in the field.

ACKNOWLEDGMENTS

I am much indebted to the Agricultural and Veterinary staff of Teso District, Uganda, who assisted in collecting the data. I should also like to express my thanks to Mr. J. B. Randall, the Director of Veterinary Services and Animal Industry, Uganda, for permission to publish the article and to Dr. J. I. Taylor, Director of Veterinary Research, Federal Government, Nigeria, for his assistance in the preparation and final drafting of the article.

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ON THE ESTIMATION OF CRUDE FIBRE IN FODDERS AND CONCENTRATES

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Almost a century has elapsed since Henneberg and Stohmann [1] proposed a method for the determination of "crude fibre" in feeding-stuffs. Their method, the so-called "Weende procedure", required feeding-stuffs to be digested for half an hour alternately with 1.25 per cent H_2SO_4 and 1.25 per cent KOH. With certain well-known modifications, this procedure is perpetuated in the Fertilizers and Feeding-Stuffs Regulations as suitable for routine analysis but, because of modern investigations into the digestibility of crude fibre and the importance of this fraction in estimating starch equivalent values, improvements have been sought. In this paper two aspects of the suitability of the determination in its present form are described, in relation to "fodders" and to "concentrates".

The determination of crude fibre as described in the Fertilizers and Feeding-Stuffs Regulations is considered adequate to meet the requirements of materials usually examined in relation to those regulations, but a more detailed specification of procedure has been found necessary for the examination of materials in a fine state of subdivision and of low crude fibre content [2]. Henneberg and Stohmann themselves had investigated the effect of the state of subdivision of a number of feeds in relation to their crude fibre content, and they showed this effect to be variable. Sometimes the fineness of the subdivision made a definite difference to the result; at other times it made very little difference. These somewhat inconclusive observations seem to have been based on results obtained with fodders only.

The original technique for filtration used by Henneberg and Stohmann was to syphon off the liquid left respectively after the acid and the alkaline digestions. Long before this technique was criticized by Steigler [3], Addyman [4] was already filtering the fluids of both digests through linen. The Fertilizers and Feeding-Stuffs Regulations specify that the acid digest should be filtered by suction through filter paper supported either by a piece of cotton cloth or by a disc of filter paper contained within the walls of a Buchner funnel. Many agricultural chemists at this stage of the determination prefer to filter by suction through linen or similar material held in position over a Buchner: this is the usual procedure in the United States where a special filter cloth is manufactured for the purpose.

EXPERIMENTAL

In order to assess to what extent the fineness of the subdivision of a single fodder might influence the estimates of its crude fibre content, a simple experiment was carried out with elephant grass (*Pennisetum purpureum*), ground in a Christy and Norris 5-in. laboratory mill to pass through three sieves differing in the size of their apertures. The crude fibre content of the grass in each state of subdivision was determined by filtering the acid digests through cloth and through filter paper respectively. All determinations were made in duplicate with the following modifications of the method described in the Fertilizers and Feeding-Stuffs Regulations:—

(i) the locally available cloth, containing 89 ends per inch, used to filter the acid digest, was held in place over a Buchner funnel by a strong rubber band;

(ii) the Whatman No. 54 filter paper used to filter the acid digest was suitably cut to fit up to, and only just up to, the walls of a Buchner funnel of 11 cm. internal diameter, and the technique for filtration conformed to the specifications detailed for the determination of crude fibre in national flour [2]; and

(iii) the residue remaining after alkaline digestion was washed in the usual way and dried for 18 hours in an oven held at 100° C. It was then transferred carefully from the filter paper to a 7-cm. flat form silica dish and dried for a further five hours. After cooling and weighing the dish and residue, the latter was heated on an electric hot-plate until charring had ceased, and then ignited for 30 minutes in a muffle furnace held at 600° C. On cooling, the weight of the dish containing the ash of the residue was determined.

The results of this experiment are shown in Table I.

Table I—Variation in the Crude Fibre Content of Elephant Grass with Fineness of Grinding

Aperture of Sieve	Crude Fibre—Per Cent of Dry Matter		
(mm.)	Cloth	Filter paper	Mean
0·80	28·76	29·37	29·06
1·20	30·66	30·86	30·76
2·40	31·42	31·63	31·52
Mean	30·28	30·62	

S.E. of the Mean for Filters 0·095.

S.E. of the Mean for aperture size 0·116.

Mean percentage difference between duplicate determinations 0·44± 0·11.

These data show that the crude fibre content of elephant grass increases progressively and significantly with decreasing fineness of grinding. No significance can be attached to the difference between the mean crude fibre content of the grass due to filtering through cloth as against filter paper, though this latter procedure gives consistently higher results.

In order further to examine the relative effectiveness of cloth and filter paper, five different cloths were compared with filter paper in the determination of the crude fibre content of seven different materials of plant origin. The cloths were: Terylene A, 48 ends per inch; Terylene B, 60 ends per inch; Terylene C, 54 ends per inch; U.S.A. filter cloth[*], style 40; Irish linen, 54 ends per inch; and Whatman No. 54 filter paper. The plant materials were ground in the power mill to pass through the sieve containing apertures of 1.2 mm. diameter and crude fibre determinations were made in duplicate in accordance with the modifications already described. The results of these determinations are given in Table II.

When the crude fibre value for each of the materials given in Table II is expressed as a percentage of the appropriate filter paper value, the data shown in Table III is compiled.

Table II—Crude Fibre, Per Cent of Dry Matter

Filters	Fodders and Faeces					Concentrates	
	Hyparrhenia	Oat Straw	Cynodon	Trifolium	Faeces (Oat Straw)	Earthnut Cake	Cassava Meal
Terylene A ..	41·35	37·01	28·78	21·82	35·19	4·03	1·82
Terylene B ..	41·73	37·18	27·92	21·32	33·89	4·17	1·72
Terylene C ..	41·17	36·58	27·49	21·67	34·21	4·13	1·73
U.S.A. Cloth ..	42·69	37·52	28·29	21·78	34·82	4·16	1·87
Linen	37·99	35·44	25·52	20·81	33·77	4·10	1·59
Filter paper ..	42·32	37·64	29·12	22·07	35·77	4·37	2·20

Mean percentage difference between duplicate determinations—0·43± 0·047.

Table III—Crude Fibre Expressed as a Percentage of the Filter Paper Value

Filters	Fodders and Faeces						Concentrates		General Mean
	Hyparrhenia	Oat Straw	Cynodon	Trifolium	Faeces (Oat straw)	Mean	Earthnut Cake	Cassava Meal	
Terylene A ..	97·71	98·32	98·83	98·87	98·38	98·42	92·22	82·73	95·29
Terylene B ..	98·60	98·78	95·88	96·60	94·74	96·92	95·42	78·18	94·03
Terylene C ..	97·28	97·18	94·40	98·19	95·64	96·54	94·51	78·63	93·69
U.S.A. Cloth	100·87	99·68	97·15	98·68	97·34	98·75	95·19	85·00	96·27
Linen ..	89·77	94·15	87·64	94·29	94·41	92·05	93·82	72·27	89·48
Filter paper	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00
Mean ..	97·37	98·02	95·65	97·77	96·75		95·19	82·80	

S.E. of General Mean for Filters, using Fodders, Faeces and Concentrates—1·22.
S.E. of the Mean for Filters, using Fodders and Faeces only—0·708.
S.E. of the Mean for Earthnut cake alone—1·07; Fiducial Limits—92·44—97·94.
S.E. of the Mean for Cassava meal alone—3·87; Fiducial Limits—72·84—92·76.

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[*] Obtained from the National Filter Media Corp., New Haven, Connecticut.

When the results shown in Table III are analysed as a whole, it is clear that filter paper gives a significantly higher value, and linen a significantly lower value, than all the other filters, which do not differ significantly from each other: the mean value for cassava meal is significantly lower than the remainder of the materials used.

If the analysis of variance is carried out on "fodders and faeces" only, the variance ratio, 2.14, fails to provide significant evidence of differences between them, but the variance ratio in respect of "Filters", 15.41, indicates that a very high order of significance is attached to these differences. The value for the U.S. Filter Cloth and for Terylene A does not differ significantly from that for filter paper, but the values for Terylene B and C and for linen are significantly lower. This result would suggest that in the estimation of the crude fibre content of fodders, and of faeces derived from fodders, the use of a carefully selected cloth for filtering the acid digest is permissible, though it is unlikely that such a cloth will possess the same degree of retentiveness as filter paper.

When the analysis of varience for "Concentrates" only (Table III) is computed, it is apparent that the divergence between the two concentrates (V.R. = 16.08) is so emphasized as to render differences between "Filters" (V.R. = 2.38) insignificant. If, however, the same data are analysed independently it is clear that for both earthnut cake and cassava meal the respective filter paper value differs significantly from all the rest, which do not differ significantly from each other.

CONCLUSIONS

It is apparent from the foregoing that the crude fibre content of a fodder may be affected significantly by its state of subdivision and by the procedure used for filtering the acid digest. Any departure from the standard procedure described in the Fertilizers and Feeding-Stuffs Regulations for filtering the acid digest, such as that of filtering through cloth, would seem permissible only if the retentiveness of that cloth is known not to differ significantly from that of filter paper. The United States filter cloth, and one of the Terylenes (A) would conform to this requirement; the linen most certainly would not.

The use either of the United States filter cloth or Terylene A as against filter paper for filtering the acid digest of concentrates such as earthnut cake and cassava meal will almost inevitably cause a significant underestimate of their crude fibre content. For these and all similar concentrates in a fine state of subdivision and of low or very low crude fibre content it is suggested that the procedure described below might be followed, and could be used with advantage as a standard routine method.

METHOD FOR THE DETERMINATION OF CRUDE FIBRE

Reagents:

1.25 per cent NaOH, make up approx. 13 g. pellet-form A.R. sodium hydroxide to 1 lit.

1.25 per cent H_2SO_4, make up approx. 7.5 ml. conc. sulphuric acid (S.G. 1.835) to 1 lit.

These reagents are carefully standardized before use.

Method:

The residue remaining after extracting 2 g. of the feeding stuff in a Soxhlet extraction apparatus for eight hours (with petroleum ether b.p. 60-80°) is allowed to air-dry overnight in its thimble. It is then transferred to a 1-lit. quick-fit conical flask. 200 ml. of 1.25 per cent sulphuric acid contained in a 400 ml. beaker are brought to the boil on an electric hot plate and transferred to the conical flask containing the feeding-stuff. An air-condenser, effective length 75 cm., is connected to the flask and the contents of the latter are brought to the boil within one minute. The boiling is kept gentle and continuous for exactly 30 min., during which time the flask is gently rotated at frequent intervals in order to mix the contents and remove particles from the sides. At the end of 30 min. the flask is removed and the contents poured at once into a Buchner funnel containing an 11 cm. Whatman No. 54 filter paper,* through which boiling distilled water has just been drawn by suction. When the liquid has drawn through, the conical flask is rinsed clean with successive washings of hot water into the funnel, and the residue in the funnel is washed with boiling water until the washings are free from acid.

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* It is important that the filter paper used in the Buchner funnel should fit up to, but only just up to, the walls of the funnel.

The determination is discarded if the time of filtration of the bulk of the 200 ml. exceeds 10 min.

The filter paper with the washed residue is now transferred to a six-inch diameter glass funnel placed in the neck of the conical flask and the residue is washed back into the flask with 200 ml. of boiling 1.25 per cent sodium hydroxide solution. The contents of the flask are boiled for exactly 30 min., the precautions given for the treatment with acid being observed. At the end of 30 min. the flask is removed from the condenser and its contents are immediately filtered through a 12.5 cm. Whatman No. 54 filter paper held in an ordinary 7.5 cm. conical funnel, the filter paper having previously been wetted with hot distilled water. The conical flask is rinsed out completely with hot distilled water and the washings are passed through the filter paper. The residue on the filter paper is washed with boiling water, then with a one per cent solution of hydrochloric acid and again with boiling water until free from acid. The residue is then washed twice with 95 per cent alcohol and three times with ether. The filter paper containing the residue is placed on a clock glass and transferred to an electric drying oven held at 100° C., where it is kept for 18 hours. The residue is then carefully scraped with the blade of a penknife from the filter paper into a tared 7 cm. silica dish, the last fibrous remnants remaining on the paper being brushed into the dish with a camel hair brush. The dish and residue are replaced in the drying oven for a further 5 hr., after which time they are cooled in a desiccator and weighed. The dish and residue are then ignited on an electric hot plate until charring has ceased, and then in a muffle furnace for exactly 30 min. at 600° C. After cooling in a desiccator, the dish and its contents are weighed again.

The loss in weight represents "crude fibre", if the determination is carried out at sea level. At higher altitudes it is necessary to apply a correction, on account of the lower boiling point of the reagents. This was investigated by Dougall [5] who suggested a correction factor derived from the equation: crude fibre (corrected) = crude fibre (30 min. at t°) $\times$ $[1-(100-t^\circ)\ 0.0102]$ where t° is the boiling point of the reagents.

ACKNOWLEDGMENTS

I wish to thank Messrs. African Explosives and Chemical Industries (E.A.) Ltd., and Messrs. Fothergill and Harvey Ltd. for kindly providing me with the Terylene cloths.

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THE PERSISTENCE OF INSECTICIDES IN TROPICAL SOILS

I—PRELIMINARY INVESTIGATIONS

By **J. Robinson**, **Royal Technical College of East Africa, Nairobi, Kenya**, and **E. T. Mesmer**, **Colonial Pesticides Research Unit, Arusha, Tanganyika**

(*Received for publication on 7th June*, 1957)

The interpretation of the entomological observations obtained in experiments on the control of soil pests in East Africa is difficult owing to the lack of information on the persistence of insecticides in local soils. Experiments were carried out at Kawanda, Uganda, with a view to obtaining reliable data, but the data obtained were so variable that it was difficult to deduce any valid conclusions, and the experiments were, in fact, shelved for a time until the experimental technique had been improved and convenient statistical procedures obtained for handling the data.

APPLICATION AND SAMPLING OF THE INSECTICIDES

In the experiments at Kawanda insecticidal dusts were applied as uniformly as possible to experimental plots and the insecticide was either left on the surface for weathering studies or hoed into the ground. Random samples of the soil were taken by means of a 1½-in. screw auger fitted with a cylindrical sleeve. The sleeve prevented the light top soil from falling off the auger and, in surface treatments, it prevented the surrounding surface insecticide falling into the sample. The soil was sampled to a depth of 6 in., ten samples being taken at each time interval.

CHEMICAL ANALYSIS

Weighed amounts of the soil samples were extracted with petroleum ether (b.p., 60–90° C.) in a Soxhlet extractor for eight hours. It was found that the extraction was quite successful providing that the water content was not so high as to give a mud; much of the water present was driven out during the extraction and collected on the upper inner surface of the extractor and the condenser. The petroleum ether extract was evaporated cautiously—using air blowing to remove the last ml. of solvent—and the D.D.T. or B.H.C. was estimated by the hydrolysable chlorine method. The moisture content of the soil was also determined by drying weighed amounts for three hours at 110° C.

RESULTS

The results, calculated on the dry weight of the soil, are summarized in Tables I and II.

TABLE I—INSECTICIDE HOED INTO SOIL

Amount of insecticide applied	Insecticide content of dry soil (p.p.m.) 0–6″ depth		Time, in days, since insecticide was applied	Rainfall since application, ins.
	Mean	Range		
10 oz./yd.^{2} of Agrocide 2 (B.H.C.) (Experiment 1)	111	350	13	2·27
	78	88	42	5·67
	85	224	78	9·69
	46	134	99	17·56
10 oz./yd.^{2} of Kensil 5% D.D.T. (Experiment 2)	292	382	6	0·88
	143	275	34	5·67
	172	286	67	9·55
	167	221	96	17·56

TABLE II—INSECTICIDE APPLIED TO SURFACE ONLY

Amount of insecticide applied	Insecticide content of dry soil (p.p.m.) 0–6″ depth		Time, in days, since insecticide was applied	Rainfall since application, ins.
	Mean	Range		
10 oz./yd.^{2} of Agrocide 2 (B.H.C.) (Experiment 3)	192	167	0	0
	74	135	13	0·93
	24	66	29	8·58
	25	43	55	11·61
10 oz./yd.^{2} of Kensil 5% D.D.T. (Experiment 4)	240	160	0	0
	190	259	2	1·5
	101	269	29	5·45
	89	261	56	7·53

The insecticide distribution was extremely variable at all the time intervals, and at first the results were considered to be meaningless. However, it was realized later that some conclusions could be drawn by means of statistical analysis. For example, the calculation of the correlation coefficient between insecticide content and time would, under certain conditions, show whether any significant change in insecticide content had occurred. These correlation coefficients are given in Table III.

TABLE III—CORRELATION COEFFICIENTS BETWEEN INSECTICIDE CONTENT AND TIME ELAPSED

Treatment	Correlation Coefficient	Significance
Agrocide 2, hoed in	—0·297	0·1 > P > 0·05 not significant
Agrocide 2, surface treatment.	—0·725	P < 0·001 highly significant
D.D.T., hoed in.	—0·233	P > 0·1 not significant
D.D.T., surface treatment.	—0·538	P < 0·001 highly significant

The values of the significance of the correlation coefficients are, strictly, only true if the regression is linear. A more rapid analysis, which gives strictly valid results, and which is also more easily interpreted, is to set up a null hypothesis; namely, that there is no difference between the insecticide contents of the soils at the various time intervals. This hypothesis is quickly tested using control charts (Davies, 1949). Control charts have the advantage of giving a graphical representation of the data, and, at the same time, a test of the statistical significance of the results. The control charts for the four experiments are given in Figs. 1–4. There is a slight tendency for the ranges in the Agrocide experiments to be out of control but the heteroscedasticity is not sufficient to affect seriously the interpretation of the Mean Control Charts. In the two experiments in which the insecticide was hoed into the soil the mean control charts indicate that there was no significant decrease in the Agrocide experiment, and a doubtful decease in D.D.T. experiment. However, the surface treatments showed a significant decrease in the case of Agrocide 2, and a tendency towards a significant decrease in the D.D.T. experiment.

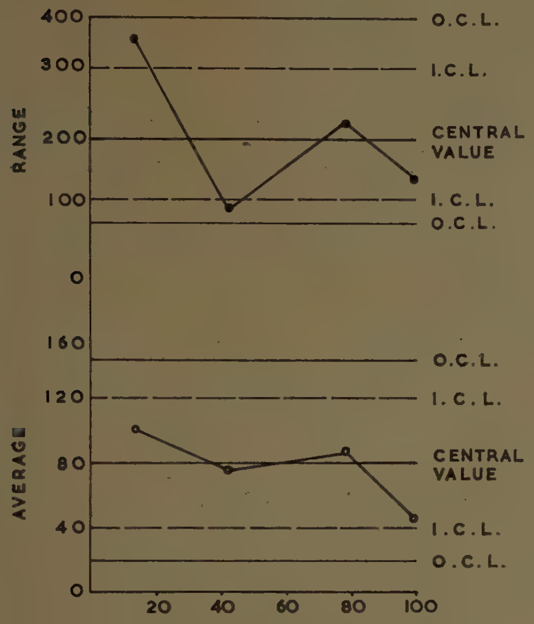
The three main causes of a decrease in insecticide content are firstly, volatilization of the insecticide; secondly, removal of the insecticide by rain; and thirdly, adsorptive migration of the insecticide to lower levels of the soil. It is doubtful whether the decrease in insecticide content in experiments 3 and 4 can be attributed to rainfall effects since the rainfall in these two experiments was less than in experiments 1 and 2 in which no significant decrease was observed. With regard to the third possibility the data of these experiments are not sufficient to draw any conclusions. However, it is plausible to postulate that volatilization of the insecticide is the chief factor contributing to the differences observed when the insecticide is hoed in or left on the surface. Soil temperature figures for Kawanda are not available, but at Arusha, Tanganyika, the surface temperature may rise to about 65° C., and the rate of decrease of the soil temperature with depth, measured by admittedly crude methods, is quite large in the first few inches. These observations are in quite good agreement with measurements made in England (Russell, 1954).

The chief difficulty in interpreting the results of these experiments arises from the large degree of variation shown by the data. Thus the value of the standard deviation within groups for experiment 2, calculated from the mean range, is 94.5. Using this estimate of the standard deviation the differences (*d*) in the means of two groups of ten samples, significant at the 5 per cent probability level, can be calculated from:—

$$t_{18} = \frac{d}{94.5\sqrt{\frac{1}{10} + \frac{1}{10}}}$$

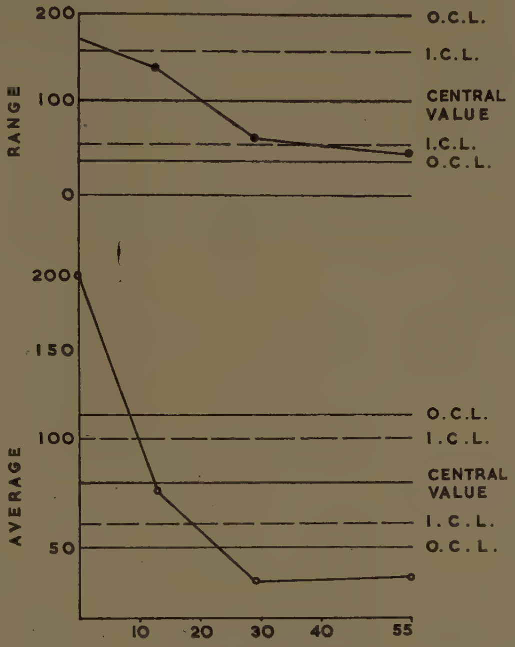
$$\text{whence } d = 89$$

Hence a decrease of approximately one-third of the original amount would be required for a significant difference in the insecticide content to be detected. Conversely, if a difference of say 15 p.p.m. is to be significant, groups of approximately 300 samples would be required to give significant results at the 5 per cent level. A more accurate assessment of sample numbers, taking into account errors of the first and second kind (Tippett, 1952), shows that for a difference of 94.5 p.p.m. to be significant groups of 27 samples would be required (Davies, 1954). The calculation of the numbers of samples required to detect a significant difference in the slopes of the regression lines is more complex, especially as the relationship between insecticide content and time is probably non-linear. However, the above analysis is sufficient to indicate the difficulties in the interpretation of data obtained from the experimental design used in these investigations. Details of experimental



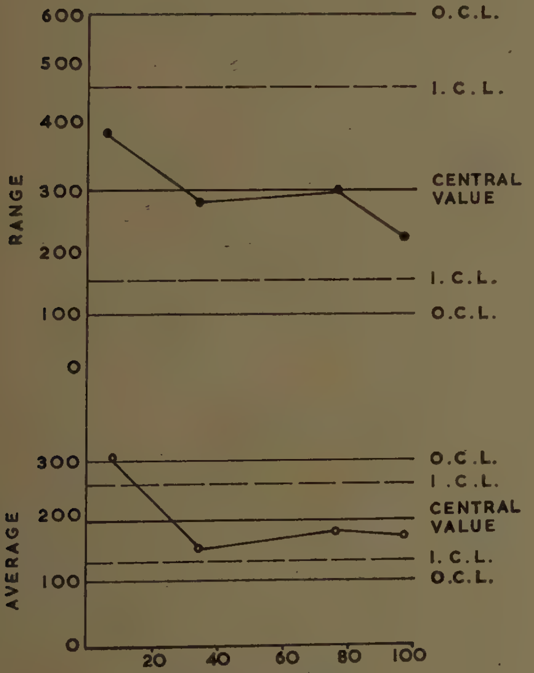
Days since treatment.

Fig. I.—Agrocide hoed into soil.



Days since treatment.

Fig. III.—Agrocide, surface treatment only.

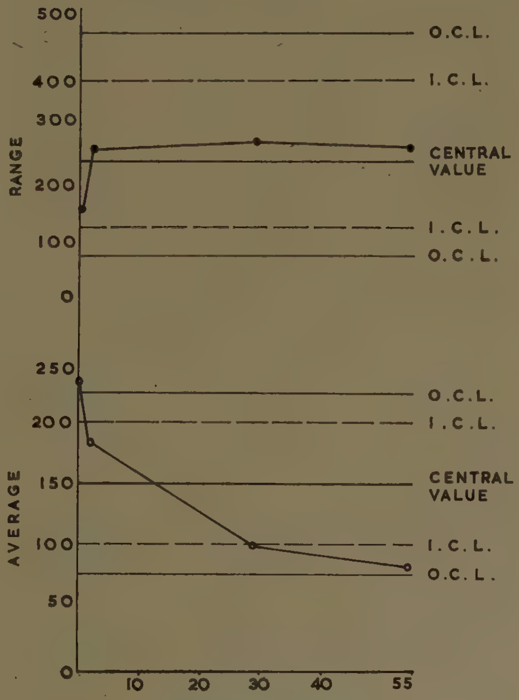


Days since treatment.

Fig. II.—D.D.T. hoed into soil.

O.C.L. = Outer Control Limit.

I.C.L. = Inner Control Limit.



Days since treatment.

Fig. IV.—D.D.T., surface treatment only

O.C.L. = Outer Control Limit.

I.C.L. = Inner Control Limit.

methods used for more precise investigations of the variation of insecticide content of soils with time will be published in subsequent papers.

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Davies, O. L. Design and Analysis of Industrial Experiments (First Edition). Oliver and Boyd, London, 1954, Table E.1.

REVIEWS IN BRIEF

PROCESSING OF CASSAVA AND CASSAVA PRODUCTS IN RURAL INDUSTRIES, by L. W. J. Holleman and A. Aten, F.A.O. Agricultural Development Paper No. 54, 1956. Obtainable from the Food and Agriculture Organization, Rome, Italy, price U.S. $1.50 or 7*s.* 6*d.*

A booklet of 115 pages which describes the cassava plant and its culture, processing of tapioca flour, baked tapioca products, examples of tapioca factories, the analysis of cassava and tapioca, and the uses of tapioca in industries such as textiles, dextrin and glue, laundry, and paper manufacture.

MANURING OF TEA IN EAST AFRICA, by R. Child. Pamphlet No. 14, Tea Research Institute of East Africa, P.O. Box 91, Kericho, Kenya.

Detailed recommendations for manuring unshaded mature tea in Kenya and Tanganyika, with notes on shaded tea, tea nurseries, and tea seed trees.

FERTILIZING FLUE-CURED TOBACCO, issued in July 1957 by the Tobacco Research Board of Rhodesia and Nyasaland, P.O. Box 1909, Salisbury, S. Rhodesia.

Fertilizer recommendations are given for the major soil types in the tobacco-growing areas of Rhodesia and Nyasaland, and there is a brief but lucid discussion of the effects of nutrients in plant growth and leaf quality in tobacco.

SUPPLEMENT TO A WORLD DICTIONARY OF BREEDS, TYPES AND VARIETIES OF LIVESTOCK, by I. L. Mason, Supplement to Technical Communication No. 8 of the Commonwealth Bureau of Animal Breeding and Genetics, Edinburgh. Published by the Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, England, 1957, price 7*s.* 6*d.*

Since the first edition of the World Dictionary appeared in 1951, there have been several changes in breed status and in breed names, and some new breeds have been described in the literature. This supplement includes both new entries and replacements for entries in the first edition of the dictionary.

TETRAHEDRON. The International Journal of Organic Chemistry. Vol. I, part I, 1957. Distributed by I. R. Maxwell & Co. Ltd., 4 and 5 Fitzroy Square, London, W.1, and Pergamon Press Inc., 122 East 55th Street, New York 22, N.Y. Subscription per volume: U.S.A. $17.00 or £6.

The special character claimed for this new journal is its fully international scope, since it is envisaged as a forum for the presentation of original memoirs on organic chemistry contributed from all parts of the world. It is intended to cover all aspects of organic chemistry, whether theoretical or practical, analytic or synthetic, physical or biological. Contributions will be printed in one of three languages, English, French, or German.

A NOTE ON THE NUTRITIVE VALUE OF RAMIE LEAVES (BOEHMERIA NIVAE)

By T. G. Cleasby* and Osman Eff. Sideek, Chemistry Department, Faculty of Agriculture, University of Khartoum

(*Received for publication on 6th May,* 1957)

The cultivation and development of ramie has been reviewed by Willimott in *World Crops*, 1954 [1]. It originated as a fibre crop in China and the Far East, where it has been used from earliest times. Only recently, however, have reports been made on the feeding value of ramie leaves. These have come mainly from Florida, U.S.A., and claim that the leaves are readily eaten by stock, and have a high protein and fat content.

The present investigation arose out of attempts during the past three years to introduce ramie as a potential cash crop in the Zande District of Equatoria Province in the Southern Sudan. It has been shown that ramie can be grown there under natural conditions, and so far, without fertilizer amendment to the soil. Should it develop into an economic crop, then a plentiful supply of fresh and dried leaves would become available throughout the year. In a country such as the Sudan, generally short of animal feeding stuffs, all potential food sources are important.

This paper records analytical data, and the results of digestibility trials carried out with ramie leaves. The remoteness of Shambat (near Khartoum) from the area where the plant was grown, necessitated all the work being done with air-dried leaves. In other words, it is the feeding value of ramie leaf hay which has been investigated.

The material employed was the leaves of *Boehmeria nivae* (L.) Gand., or white ramie. It was propagated from clones introduced from Malaya, originating from Florida Everglades, and clones from the Botanic Gardens, Entebbe, Uganda.

EXPERIMENTAL

Analytical Results

The results of a series of analyses carried out on various samples of the leaves have been recorded in Table I. The usual A.O.A.C. methods were used, each determination being done in duplicate. The nutrients have been expressed on a percentage dry-matter basis.

Samples 1, 2 and 3 were from plants grown in nurseries, and 4, 5 and 6 from the field. Samples 4 and 6 were from the bulk used in the digestibility trials I and II, and samples 1 and 2 were mixed for the digestibility trials with cotton seed hulls.

Some of the variation between the samples may be accounted for by different times of harvesting, although in each case the stand was cut at a time thought to be optimum for the fibre.

Digestibility Trials

Three digestibility trials were carried out on separate consignments of the leaves. Sheep and goats, in duplicate, were used as the experimental animals. They were fed during the trial in digestibility crates which automatically separated and collected the faeces. The dried ramie leaves proved to be palatable and readily eaten by the animals as long as they were well dried, and had not deteriorated during storage.

TABLE I

Origin Sample No.	Malayan 1	Malayan 2	Uganda 3	Malayan 4	Malayan 5	Malayan 6	Average
Mineral matter	20·2	16·4	19·6	18·8	21·5	23·4	20·0
Organic matter	79·8	83·6	80·4	81·2	78·5	76·6	80·0
Crude Protein	24·8	22·8	18·7	22·7	23·1	17·92	21·7
Ether Extract	6·4	6·5	7·0	8·6	7·9	7·64	7·3
N-free Extract	36·5	41·6	39·3	38·6	35·4	40·72	38·7
Crude Fibre ..	12·1	12·7	15·4	11·3	12·1	10·32	12·3
Silica	7·0	5·3	9·2	5·5	9·0	10·0	7·7
Calcium ..	6·9	6·1	4·9	—	6·7	—	6·2
Phosphorus ..	0·45	0·49	0·46	—	0·45	—	0·47

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* Present address: Agronomist to the Tongaat Sugar Co. Ltd., P.O. Box 5, Maidstone, Natal.

Trial 1.—This was carried out using dried ramie leaves alone with sheep. The results are tabulated in Table II.

Trial 2.—This was carried out using dried ramie leaves alone, but, in this case, goats were used as the experimental animals. The results are summarized in Table III.

Trial 3.—The initial consignment of ramie leaves was too small to be fed alone to animals in a digestibility trial. It was, therefore, made into a 20 per cent mixture with cotton seed hulls, and fed as such. The choice of cotton seed hulls as a roughage arose from other work [2], which will be reported elsewhere, investigating the potential feeding value of cotton seed meal and hull mixtures. It was possible to compare figures for these mixtures with those for ramie leaves and cotton seed hulls. The results of the digestibility trial have been recorded in Table IV, and this comparison made in Table V.

TABLE II

TABLE II—TWO SHEEP FED 750 GMS./DAY OF AIR-DRIED LEAVES EACH FOR 10 DAYS. TOTAL DRY MATTER FED TO EACH ANIMAL = 6,894 GMS.

	Analysis		Digestibility Coeffs.			Digestible Nutrients 100 lbs. dry matter fed
	as fed	D.M.	Sheep 1	Sheep 2	Average	
Moisture	8·08	0·0				
Organic	70·39	76·6				
Crude Protein	16·49	17·9	58·82	59·88	59·4	10·6
Ether Extract	7·03	7·6	27·40	25·40	26·4	2·0
N-free Extract	37·37	40·7	44·86	50·40	47·6	19·4
Crude Fibre	9·50	10·3	49·16	49·16	49·2	5·1
Mineral	21·53	23·4				
Silica	9·15	10·0				

T.D.N. = 39·6
P.S.E. (Kellners) = 35·8

TABLE III—TWO GOATS FED 300 GMS. DRIED RAMIE LEAVES/DAY FOR 10 DAYS. TOTAL DRY MATTER FED TO EACH ANIMAL = 2,711 GMS.

	Analysis		Digestibility Coeffs.			Digestible Nutrients/ 100 lbs. dry matter fed
	as fed	D.M.	Goat 1	Goat 2	Average	
Moisture	9·67	0·0				
Organic	73·4	81·2				
Crude Protein	20·5	22·7	56·5	55·7	56·2	12·8
Ether Extract	7·8	8·6	44·2	35·8	40·0	3·4
N-free Extract	34·9	38·6	41·6	52·8	47·2	18·2
Crude Fibre	10·2	11·3	33·0	32·2	32·6	3·7
Mineral	17·0	18·8				
Silica	5·0	5·5				

T.D.N. = 42·4
P.S.E. (Kellners) = 37·8

TABLE IV—AMOUNT OF MIXTURE FED TO SHEEP ON A DRY-MATTER BASIS, 1,807 GMS. RAMIE LEAVES AND 9,087 GMS. COTTON SEED HULLS

	Analysis of mixture D.M.	Digestibility Coeffs.			Digestible Nutrients/ 100 lb. D.M. fed
		Sheep 1	Sheep 2	Average	
Moisture	0·0				
Organic	94·0	42·0	37·1	40·1	37·7
Crude Protein	9·4	24·8	23·1	24·0	2·3
Ether Extract	3·5	62·9	62·9	62·9	2·2
N-free Extract	41·3	47·5	45·5	46·5	19·2
Crude Fibre	39·8	40·4	30·7	35·6	14·2
Mineral	6·0				
Silica	1·5				

T.D.N. = 40·7
P.S.E. (Kellners) = 16·7

TABLE V—COMPARISON WITH DIGESTIBILITY DATA FOR COTTION SEED HULL AND MEAL MIXTURES.

	20% Ramie	Cotton seed meal 10%	Cotton seed meal 20%
Digestible Protein per 100 lb. D.M. fed ..	2·3	2·9	4·8
T.D.N.	40·7	45·1	50·9
P.S.E. (Kellners) ..	16·3	18·9	26·1

CONCLUSION

The analysis of dried ramie leaves suggests that it should be a potentially rich source of protein, fat and calcium. It is readily eaten by sheep and goats if the leaves have been carefully dried and well stored. It becomes unpalatable when deterioration sets in due to fermentation caused by imperfect drying or bad storage. Ramie leaves contain a high silica content, which very possibly detracts from its feeding value. The crude fibre content of the leaves is low.

The digestibility trials 1 and 2 show a tolerably good agreement with each other, and that the leaves alone have a generally low feeding value. This view is confirmed by the third digestibility trial in conjunction with cotton seed hulls. Cotton seed meal shows a similar analysis to ramie leaves, with the exception of a much higher crude protein (34 per cent). Table V indicates the superior feeding value of the mixtures containing cotton seed meal.

A comparison is given in Table VI between ramie leaves and other dried plant material commonly used for feeding. Abu Saba'en is a *sorghum vulgare*, very commonly cut as a fodder crop in the Northern Sudan, and Lubia Afin (*Dolichos lablab*), a leguminous fodder crop also used.

The true value of ramie leaves would appear to be as a supplementary feed, moderately rich in protein. Supplies of the leaves have so far been insufficient for full-scale feeding trials to be undertaken, and until this is done it is difficult to say what place they will eventually take in the feeding of animals in regions where they are available. This work principally shows that the leaves are palatable, and that they can provide approximately 11.7 lb. of digestible protein per 100 lb. dry matter fed. The figures in Table VI indicate that the leaves are of comparable, though slightly lower, feeding value to lucerne hay in good condition.

ACKNOWLEDGMENTS

The thanks of the authors are due to Dr. S. G. Willimott, until lately Senior Research Officer at the Yambio Experimental Farm, who was responsible for the introduction of ramie clones to the Zanda District of Equatoria Province, and at whose suggestion this nutritional work was undertaken. He was responsible for the collection, drying and transport of the leaves, and his interest in this paper is greatly appreciated.

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[1] Willimott, S. G., *World Crops*, *6*, October, 1954.

[2] Unpublished results, Faculty of Agriculture, University of Khartoum.

TABLE VI

FODDER		ANAYLSIS					DIGESTIBLE NUTRIENTS						
		Crude Protein	True Protein	Ether Extract	N-free Extract	Crude Fibre	Crude Protein	True Protein	Ether Extract	N-free Extract	Crude Fibre	T.D.N.	P.S.E. (Kellners)
Ramie leaves	..	21·7	4·2	7·3	38·7	12·3	11·7	—	2·7	18·8	4·4	41·0	36·8
4 Abu Saba'en	A	4·25	4·1	0·84	55·0	32·1	1·6	1·57	0·49	34·6	21·2	58·5	39·6
	B	5·35	14·7	1·02	55·8	32·1	2·2	1·61	0·32	34·9	18·5	56·0	37·5
4 Lubia Afin	..	16·6		2·9	34·1	37·1	12·3	10·6	1·8	18·1	24·8	59·2	36·4
Lucerne Hay*	..	18·9		1·1	30·6	25·4	13·9	—	—	20·4	12·2	46·5	37·1
Meadow Hay*	..	13·5		3·0	40·5	19·3	9·2	—	1·0	25·7	15·0	52·2	46·0

*Good quality.

BREED AVERAGES OF RECORDED COWS IN KENYA FOR THE YEAR ENDING 1st JULY, 1957, BY THE E.A. MILK RECORDING SCHEME, P.O. BOX 478, NAKURU

	Number of Animals	Milk Galls.	Days in Milk	B.F. lb.	B.F. %	Calving Interval Days
Ayrshire—						
Pedigree Cows	437	634·67	280	259·14	4·08	385
Exclusions	101	—	—	—	—	—
Pedigree Heifers	139	545·80	287	225·29	4·13	—
Exclusions	33	—	—	—	—	—
N.P. Cows	2,309	522·53	274	215·14	4·12	376
Exclusions	517	—	—	—	—	—
Grade Heifers	309	481·55	282	199·08	4·13	—
Exclusions	68	—	—	—	—	—
All	3,194	534·92	276	220·05	4·11	423
Exclusions	719	—	—	—	—	—
Total Recorded Lactations—3,913 Cows in 63 herds=35·32% of Grand Total.						
Friesland—						
Pedigree Cows	229	734·03	281	268·65	3·66	475
Exclusions	71	—	—	—	—	—
Pedigree Heifers	47	651·08	286	250·77	3·85	—
Exclusions	29	—	—	—	—	—
Grade Cows	2,201	684·80	285	231·30	3·38	427
Exclusions	382	—	—	—	—	—
Grade Heifers	436	453·64	286	174·28	3·84	—
Exclusions	43	—	—	—	—	—
All	2,913	653·53	285	226·01	3·46	431
Exclusions	483	—	—	—	—	—
Total Recorded Lactations—3,395 Cows in 35 herds=30·65% of Grand Total.						
Guernsey—						
Pedigree Cows	110	628·85	292	295·77	4·70	421
Exclusions	18	—	—	—	—	—
Pedigree Heifers	32	561·57	293	265·38	4·73	—
Exclusions	7	—	—	—	—	—
Grade Cows	905	523·84	275	235·67	4·50	409
Exclusions	247	—	—	—	—	—
Grade Heifers	198	499·98	285	228·91	4·58	—
Exclusions	69	—	—	—	—	—
All	1,245	530·29	278	240·66	4·54	410
Exclusions	341	—	—	—	—	—
Total Recorded Lactations—1,586 Cows in 43 herds=14·32% of Grand Total.						
Jersey—						
Pedigree Cows	156	568·78	288	315·23	5·54	408
Exclusions	32	—	—	—	—	—
Pedigree Heifers	61	479·74	286	266·79	5·56	—
Exclusions	18	—	—	—	—	—
Grade Cows	796	485·11	276	247·36	5·10	377
Exclusions	201	—	—	—	—	—
Grade Heifers	217	413·00	276	214·69	5·20	—
Exclusions	87	—	—	—	—	—
All	1,230	482·73	278	251·17	5·20	382
Exclusions	338	—	—	—	—	—
Total Recorded Lactations—1,568 Cows in 50 herds=14·15% of Grand Total.						
Red Poll—						
Pedigree Cows	16	555·71	286	199·01	3·58	337
Exclusions	6	—	—	—	—	—
Pedigree Heifers	2	576·95	305	218·23	3·78	—
Exclusions	5	—	—	—	—	—
Grade Cows	232	495·97	287	199·35	4·02	418
Exclusions	59	—	—	—	—	—
Grade Heifers	11	474·01	282	188·46	3·98	—
Exclusions	4	—	—	—	—	—
All	261	499·41	286	199·02	3·99	411
Exclusions	74	—	—	—	—	—
Total Recorded Lactations—335 Cows in 7 herds=3·02% of Grand Total.						

BREED AVERAGES OF RECORDED COWS IN KENYA FOR THE YEAR ENDING 1ST JULY, 1957 BY THE E.A. MILK RECORDING SCHEME, P.O. BOX 478, NAKURU—(*Contd.*)

	Number of Animals	Milk Galls.	Days in Milk	B.F. lb.	B.F. %	Calving Interval Days
SHORTHORN—						
Pedigree Cows	34	542·10	289	210·83	3·89	408
Exclusions	12	—	—	—	—	—
Pedigree Heifers ..	3	393·35	305	163·20	4·15	—
Exclusions	0	—	—	—	—	—
Grade Cows	189	535·23	280	220·93	4·13	467
Exclusions	31	—	—	—	—	—
Grade Heifers	8	553·41	288	226·78	4·10	—
Exclusions	4	—	—	—	—	—
ALL	234	535·03	286	218·92	4·09	455
Exclusions	47	—	—	—	—	—
TOTAL RECORDED LACTATION;—281 Cows in 11 herds=2·54% of Grand Total.						
OVERALL AVERAGE—						
All Cows Pedigree ..	982	642·23	283	271·72	4·23	429
Exclusions	240	—	—	—	—	—
All Heifers Pedigree ..	284	549·42	287	242·23	4·41	—
Exclusions	92	—	—	—	—	—
All Cows N.P.	6,632	571·50	279	226·79	3·97	401
Exclusions	1,437	—	—	—	—	—
All Heifers N.P. ..	1,179	462·12	283	197·88	4·28	—
Exclusions	275	—	—	—	—	—
ALL ANIMALS	9,077	564·26	280	228·37	4·05	405
ALL EXCLUSIONS ..	2,001	—	—	—	—	—
TOTAL RECORDED LACTATIONS—11,078 Cows in 209 herds=100% of Grand Total.						

NOTES.—(1) All lactations are of 305 days or under.
(2) All lactations of 204 days or under are EXCLUDED.

REVIEW

THE MULCHING OF VEGETABLES, by Patricia Rowe-Dutton, published by the Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, England, 1957, pp. 169, Price: 20*s*.

This book deals very thoroughly with the mulching of Asparagus, Brassicas, Cucurbits, Peas, Beans, Field Tomatoes, Salad and Root Crops: more than 50 different kinds of mulching materials are dealt with. The East African planter, agriculture and forestry officer, is intensely interested in any material which will help to conserve soil moisture and in many cases will reduce surface soil temperature. Whilst much of the information in this book refers to temperate conditions, a wealth of information and ideas is presented which has direct bearing on the great East African problem—"how to conserve soil moisture". The use of polythene as a mulch is not extensively dealt with, and the suggestion that black polythene is more suitable than the transparent product, because it raises the soil temperature, is the reverse effect to what we nornormally seek in a mulch in East Africa. There can be little doubt, however, polythene could play a big role in East Africa as a mulch, once the economies of the product fit the crop.

The book is well produced, and the tea and coffee planter, agriculture and forestry officer will find the book well worth 20*s*. The Preface suggests that if the present book is well received, a further publication covering the mulching of fruit crops and tropical crops may be attempted. Such a book would be of immense value to the tropical world, and it is sincerely hoped it will be produced.

W.B.M.

REVIEW

INDUSTRIAL FIBRES, 1956. A review of production, trade, etc., relating to cotton, wool, rayon and other man-made fibres, mohair, silk, flax, jute manufactures, sisal and other hemps, coir and kapok: 216 pages, price 5s. net (5s. 7d. per copy post free). Obtainable from H.M. Stationery Office, or from the Secretary, Commonwealth Economic Committee, 2, Queen Anne's Gate Buildings, Dartmouth Street, London, S.W.1.

World production of the chief industrial fibres showed a marked rise in 1955/56 and reached a record level. Output in the free world rose by some 12 per cent compared with 1954/55 and the estimated total of 28,300 million lb. constituted an all-time record. Increases were recorded for each of the major varieties, the figures for man-made fibres and jute being particularly impressive. Total fibre production in the Commonwealth has continued to rise, appreciable increases in wool, jute and man-made fibres being recorded compared with the previous season, although sisal output was virtually unchanged, and cotton production fell by about five per cent.

World consumption of apparel fibres again increased during the period under review, but the improvement was not sufficient to prevent a further rise in stocks of cotton; by contrast, stocks of wool and jute declined between 1955 and 1956. Prices of the different industrial fibres showed somewhat divergent trends, but on a balance quotations declined during 1955 and the early part of 1956, although they became much firmer towards the end of the year during the Suez crisis.

PRODUCTION

Total fibre production in 1955/56 rose by 12 per cent compared with 1954/55, both apparel and non-apparel fibres showing marked improvements. The Commonwealth produced a larger proportion of the world output of wool, jute and the newer man-made fibres than in the previous season, but a somewhat lower share of cotton, hemp and rayon.

The review summarizes developments in cotton production for the season 1955/56 and points out that the total crop in the non-Communist world was nearly 4 per cent larger than in the previous season, owing chiefly to a rise in United States output, where a substantial rise in the yield per acre more than offset a 12 per cent reduction in the planted acreage. Wool production during the season also rose by 4 per cent, while there was an increase of 37 per cent in the output of man-made fibres. Among the non-apparel fibres there was a particularly marked rise in jute production due to the larger acreages licensed in Pakistan.

PRICES

Prices of the main natural fibres in world markets tended on balance to fall slightly during 1955 and the earlier part of 1956. In the final quarter of 1956, however, quotations hardened quite substantially under the influence of the Middle East situation and the closing of the Suez Canal. During the last two seasons cotton prices continued to be dominated by the stock position in the United States, the sharp reduction in quotations during the first half of 1956 being primarily the result of the American decision to export surplus cotton at competitive prices. The 1955/56 wool selling season opened with a sharp fall in prices, but thereafter the market steadied and from Easter, 1956, until the close of the year quotations moved steadily upwards. Silk and flax prices fell during most of the 1955/56 season, while jute prices, after experiencing a marked reduction in 1955, became firmer by the end of 1956. On the other hand sisal prices experienced a partial recovery in 1955, but fell away in the following year.

UNITED KINGDOM PRICE INDICES OF SELECTED INDUSTRIAL FIBRES
1947 = 100 (except flax: 1948 = 100)

CALENDAR YEAR	Cotton (American)	Wool	Silk	Flax	Sisal	Jute
1934-38 average	31	48	32	37	28	21
1951 average	227	420	147	172	305	200
1952 average	192	228	151	140	211	126
1953 average	155	261	160	116	124	98
1954 average	161	250	146	116	113	107
1955 average	155	225	136	113	107	102
1956 average	132	228	128	103	103	104
December, 1955	145	213	126	105	105	91
December, 1956	128	254	129	107	99	127

TRADE

At the present time the Commonwealth provides almost all the world's jute entering international trade, together with nearly four-fifths of the wool, two-fifths of the hemp, one-sixth of the cotton and one-tenth of the man-made fibres. On balance the Commonwealth is a substantial exporter of industrial fibres, since its net exports of wool, jute and hemp outweigh its net imports of cotton, flax, rayon and silk. In the immediate post-war period net exports from the Commonwealth were much reduced; in 1947 they amounted to only 1,100 million lb. compared with 1,900 million lb. before the war. Since then, however, the position has much improved, so that by 1955 the export balance came to around 2,100 million lb. and in the following year it is believed to have been even higher. The export figures for wool, jute and hemp alone have risen by over 60 per cent compared with 1947 from 1,600 million lb. to 2,600 million lb.

Supplies from Commonwealth countries play a dominating role in the United Kingdom's import trade in most industrial fibres. In the majority of cases, too, their proportion of the total is now considerably greater than before the war. Cotton provides an illustration of this trend, since Commonwealth countries (excluding the Sudan in all cases) provided about one-fifth of total United Kingdom cotton imports in the two years 1955 and 1956 compared with 16 per cent before the war. About 85 per cent of this country's wool imports are normally drawn from the Commonwealth, and in the case of hemp the proportion is over 80 per cent, or double the pre-war average. All the United Kingdom's jute and coir come from Commonwealth sources. The following table shows total United Kingdom imports of the main fibres, together with the proportion coming from Commonwealth sources.

CONSUMPTION AND STOCKS

Total consumption of the main apparel fibres rose in 1955/56 for the fourth year in succession. The largest individual increase occurred in rayon and other man-made fibres, whose off-take is estimated to have risen by about 14 per cent compared with the previous year. On the other hand, cotton consumption during 1955/56 rose more slowly than in recent years, partly due, it would seem, to the uncertainty surrounding cotton prices. Wool consumption rose in all the major consuming countries apart from France and Italy, and the total is estimated to have increased by about 2 per cent. There was a marked divergence of trend in stock movements during 1955/56. Cotton stocks continued to grow despite the efforts of the United States administration, and by the end of the season the world total was 6 per cent higher than a year earlier and was the heaviest since 1939. By contrast, stocks of wool and jute fell quite substantially between 1955 and 1956, but there was a rise in those of hard hemp.

NEW FIBRES

The section devoted to the newer man-made fibres has again been considerably expanded. Production of these fibres continues to increase rapidly and in 1955 amounted to over 550 million lb. or 40 per cent more than in the previous year. Nylon is still the predominant member of the group, but with the increasing demand for the newer fibres, such as Terylene, Orlon and Acrilan, it accounts for a smaller proportion of total output. New plants are being erected in many countries and planned world capacity for the end of 1957 is estimated at nearly 1,000 million lb.

UNITED KINGDOM IMPORTS OF FIBRES SHOWING COMMONWEALTH SHARE OF TOTAL

FIBRE	Unit	Average 1934–38	1951	1952	1953	1954	1955	1956
TOTAL IMPORTS—								
Cotton	million lb. ..	1,390	1,011	595	748	836	662	752
Wool (actual weight) ..	million lb. ..	846	506	694	827	684	721	702
Hemp (inc. sisal)	thousand tons	94	108	86	88	95	110	92
Coir	thousand tons	10	26	21	28	37	29	23
Jute	thousand tons	187	114	100	173	125	132	124
PROPORTION FROM THE COMMONWEALTH—								
Cotton (*a*)	per cent ..	16	14	23	21	17	22	18
Wool	per cent ..	81	94	87	79	86	87	82
Hemp (inc. sisal)	per cent ..	41	76	77	81	84	84	84
Coir	per cent ..	100	100	100	100	100	100	
Jute	per cent ..	100	100	100	100	100	100	100

(*a*)—Excluding Sudan throughout.

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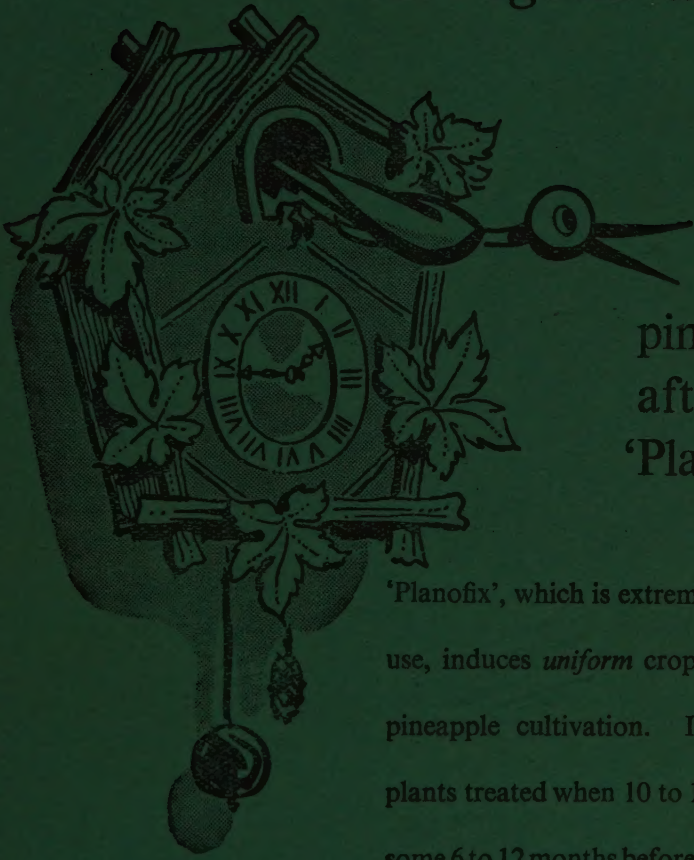

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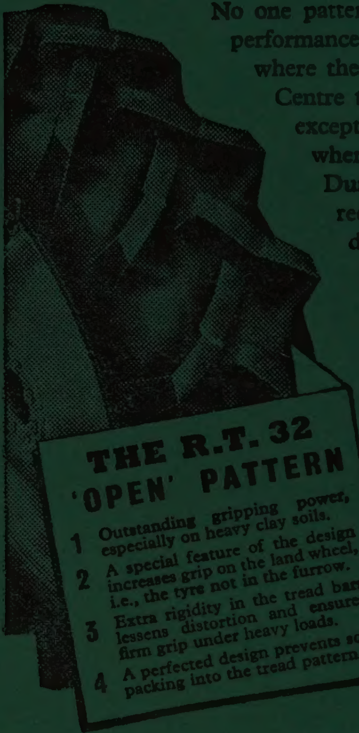

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